Elements of Electrical Technology

Instructional-cum-Practical Manual

Volume I

For Class XI

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Project Coordinator

राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्

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Foreword

The programme of vocationalization of higher secondary education has been accepted by the country as it holds forth great promise for linking education with the productivity and economic development of the country by providing education for better employability of the youth.

In view of the importance of the programme, the NCERT is making an all out effort to provide academic support to the implementing agencies in the States. One of the major contributions of the NCERT is in the field of curriculum development and in the development of model instructional materials The materials are developed through workshops in which experts, subject specialists, employers, representatives, curriculum framers and teachers of the vocational course are involved.

The present manual on Elements of Electrical Technology (Volume I) has been developed in the manner described above and is meant for the students studying lineman and allied vocations. It is being published for wider dissemination amongst students and teachers throughout the country. I hope that they will find the manual useful.

I am grateful to all those who have contributed to the development of this manual I must acknowledge also the immense interest taken by Prof. A K. Mishra, Head, Department of Vocationalization of Education in inspiring his colleagues in their endeavours to develop the instructional material. Shri S Ray, Lecturer functioned as the project coordinator for development of this title in association with Dr. A.P. Verma, Reader. They have my appreciation and thanks for planning, designing and conducting the workshops, for technical editing and for seeing this manual through the press

Suggestions for improvement of this manual will be welcome.

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Preface

Ever since the introduction of vocationalization in our school system by several States and Union Territories in our country, the paucity of appropriate instructional materials has been felt as one of the major constraints in implementation of the programme and a source of great hardship for pupils offering vocational studies at the higher secondary stage.

The Department of Vocationalization of Education of the National Council of Educational Research and Training, New Delhi has started a modest programme of developing instructional materials of diverse types to fill up this void in all major areas of vocational education. The task is too gigantic to be completed by any single agency but the model materials being developed by us might provide guidance and impetus to the authors and agencies desiring to contribute in this area These are based on the national guidelines developed by a Working Group of experts constituted by the NCERT

The present manual is on Elements of Electrical Technology (Volume I) and is meant for the pupils and for the teachers teaching Lineman and allied vocations being offered in a number of States. It contains activities (practical exercises) to be performed by pupils with simple steps to follow, precautions to be taken and data to be recorded and processed Each activity is complete with the objectives, relevant information, procedure, evaluation, etc It is hoped that the users will find them immensely useful

The experimental edition of the manual was developed by a group of experts in a workshop held at the Technical Teachers Training Institue, Chandigarh. The same was reviewed and revised through a committee of experts in a workshop held at the National Council of Educational Research and Training. The names of the contributors and reviewers are mentioned elsewhere and their contributions are admirably acknowledged Shri S Ray, Coordinator of this project deserves special thanks for editing and bringing the manual in its present form. The assistance of all in the Technical Teacher's Training Institute, Chandigarh and the Department of Vcationalization of Education, NCERT is also gratefully acknowledged.

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Acknowledgement

The following experts participated in the workshops conducted by the NCERT Their participation as contributors or reviewers is gratefully acknowledged.

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About the Manual

Under the programme of Vocationalization of Education about fifty different vocational courses in the areas of engineering and technology have been introduced by twelve States and four Union Territories so far. These courses have been running for the last seven or eight years. From the very beginning the Department of Vocationalization of Education in the NCERT has been working hand in hand with the State organization concerned, through various programmes organized for State officials, vocational teachers and others. In fact, by now the department has conducted on-the-spot studies of vocational programmes in a large number of States to find out the merits and demerits of the programme and to suggest appropriate measures to resolve the problems in "engineering and technical vocational education". These programmes have revealed that there was a great dearth of suitable instructional materials; the need for practical manuals, especially, was urgently felt The development of instructional materials and the imparting of practical training become even more important when one considers the purpose for which the vocationalization of education programme was launched. The main aim of the programme is to prepare the pupil for purposeful and gainful employment (wage-employment or self-employment).

The department constituted a Working Group in 1982 to formulate guidelines for models for a variety of instructional materials.

Based on the guidelines formulated by the Working Group, Lineman was selected by the department with the request from the Directorate of Industrial Training and Vocational Education, Government of Haryana, Chandigarh for the purpose of development of instructional materials in a phased manner. To begin with, the development of instructional-cum-practical manuals has been taken up.

The content of the 'Lineman' course was thoroughly analyed and it was felt that six manuals would be necessary to cater to the needs of the course. The present manual on Elements of Electrical Technology (Volume I) is one of them This manual is intended to help both teachers and pupils. Each activity is complete with specific objectives, related information, equipment and materials, procedure, observations, precautions and questions for evaluation. In order to acquaint the pupils about each activity, the teacher should provide them with required theoretical knowledge or information related to the activity. This will help the pupils to understand the activity properly and enable them to perform it correctly and effectively.

In order to meet the stipulated objectives, the activity includes the study and operation of tools and instruments which a lineman would be required to use in his professional career.

The evaluation of the activities performed by the pupils shall be based on the specific objectives. The teacher shall evaluate all the aspects which are relevant to achieve the specific objectives This will contribute towards the "expected behavioural outcome". Evaluation is

an important aspect of performing the activities Each activity should be assessed through evaluation based on knowledge, acquired skills and competencies, attitude and aptitude towards work, activity performance, application, maintenance of activity record Tabular representation of a suggested evaluation scheme is as follows

S.No	Components	Marks allotted	Marks awarded
(i)	Knowledge	20	
(ii)	Acquired skills and competencies	35	
(iii)	Attitude and aptitude towards work	15	
(iv)	Activity performance	10	
(v)	Application	10	
(vi)	Maintenance of activity record	10	
	Total Marks	100	

At the end of each activity, some questions for evaluation are given The pupils shall answer these questions on completion of each activity and teacher shall examine them. If required, necessary corrections and suitable suggestions should be incorporated by the teacher. However, the answers to these questions should not be considered for the purpose of awarding final marks or grades

Contents

ACTIVITY NO. 1

Familiarization with Substation

Specific Objectives

(i) To recognize various types of equipment in a substation

(ii) To study the basic function of each equipment

(iii) To understand the basic single-line diagram

Related Information:

A substation is a link between high-voltage transmission and low-voltage distribution systems For this function various types of equipment is used This can be divided into the following major categories:

(i) Transformers. This is used to change the level of the voltage

(ii) Interconnecting and switching equipment. This is used for interconnecting, disconnecting and isolating various sections of the lines This includes circuit breakers, isolators and busbar.

(iii) Protective gear This is used to protect the different equipment against faults. This includes various types of relays, circuit breakers, fuses

(iv) Metering. This section measures various guantities like voltage, current, power, energy, frequency, temperature, etc

(v) Supporting structures and insulators: Supporting steel structure provides the required mechanical strength and support to various types of equipment and lines The insulator provides necessary insulation between live lines or terminals and supporting structure (which is at earth potential)

Procedure

(i) Observe each equipment to recognize it and to learn its name and basic functions

(ii) Observe, also, a pole-mounted substation

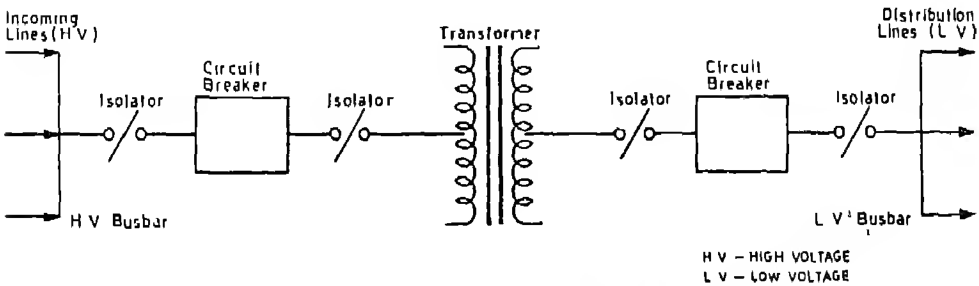


Fig 1 1 Simplified single-line diagram (basic) of a typical substation

Tabular Record of Observations

(a) At a substation.

S.No.	Name of the equipment	Basic rating	Basic function
1.	Incoming lines	(i) voltage . .... (ii) type of conductor	
2.	Tower/pole	(i) Shape . . . (ii) Height .	
3.	Insulators	(i) Type . . . .. (ii) Number ..	
4.	Isolator		
5.	Busbar		
6.	Circuit breaker		
7.	Transformer	(i) MVA . (ii) KV .. .	
8.	Name of the meters in the control room	(i) (ii) (iii) (iv) (v) (vi)	

Repeat serial No 1 to 6 for low-voltage line.

(b) Tabular record of observation at pole-mounted substation.

S.No	Name of the equipment	Basic rating	Basic function
1.	Incoming lines	(i) voltage . ... (ii) type of conductor	
2.	Pole	(i) Shape . .. . (ii) Height .	
3	Insulators	Type . . .	
4	Isolators		
5	Fuses		
6	Transformer		

(c) Note the safety precautions observed by the lineman while working
(i)
(ii)
(iii)
(iv)
(v)

Precautions

(i) Follow strictly the instructions given by the instructor while visiting a substation
(ii) Do not touch any equipment

Questions

(i) Make simple sketches of a tower, pole, insulator and conductor.
(ii) Show the location of the following on plain paper. transformer, circuit breakers, control room, etc

(iii) Explain the basic functions of the following:
   (a) Substation
   (b) Insulators
   (c) Circuit breaker
   (d) Transformer
   (e) Control room
   (f) Busbar
   (g) Isolator

(iv) Why is rubber matting used in the control room?

ACTIVITY NO 2

Demonstration of Batteries

Specific Objectives

(i) To distinguish between various types of batteries.

(ii) To learn the construction of a lead acid battery

(iii) To check the charging condition of the battery

(iv) To learn maintenance precautions of a lead acid battery

Related Information

(i) The electro-chemical reaction between electrodes (positive and negative) and electrolytes generates electrical voltage between the electrodes.

(ii) In rechargeable (lead acid) batteries, the electro-chemical reaction is reversible whereas in other batteries (such as dry cells) it is not.

(iii) The lead acid batteries have the following reactions

Battery charged	Battery discharged
PbO_2+Pb+	$PbSO_4+PbSO_4+$
$2H_2SO_4$	$2H_2O$
(+plate)+(−plate)	(+plate)+(−plate)
= +electrolyte	

On discharging, the sulphuric acid reacts with lead peroxide to form water and the specific gravity of the electrolyte decreases. On charging, the sulphuric acid concentration increases. This accounts for the increase of specific gravity on charge.

The voltage of each cell (two electrodes and electrolyte) is 2 volts (nominal). To get a higher voltage, a number of cells are connected in series, e g for 6 volts 3 cells, and for 12 volts, 6 cells are connected in series

Equipment and Materials

(i) Dry cells 1 5V

(ii) Dry cell batteries 6V, 9V

(iii) Lead acid battery (charged) 6 or 12V, 100AH

(iv) Lead acid battery (discharged) 6 or 12V, 100 AH

(v) Dismantled old battery parts mounted on a board

(vi) Multimeter.

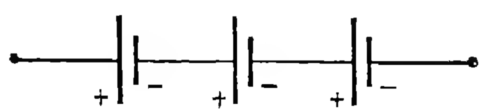


Fig 2 1 Cells connected in series

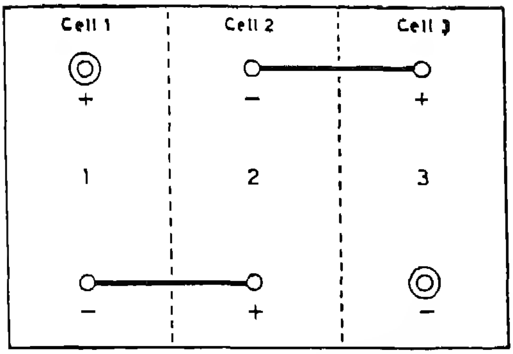


Fig 2.2 Top plate of a 6V lead acid battery

Procedure (Demonstration)

(i) Observe different batteries (dry and lead acid).

(ii) Measure the voltage of each cell of the battery.

(iii) Check the specific gravity of the electrolyte of each cell.

(iv) Study the parts of a lead acid storage battery

Tabular Record of Observations

Tabulate your observations both for charged and discharged batteries in the following tabular form

Detailed observations for lead acid batteries:

(a) Charged battery

S No of Cell	1	2	3	4	5	6	Total
Voltage							
Specific Gravity							

(b) Discharged battery

S No of Cell	1	2	3	4	5	6	Total
Voltage							
Specific Gravity							

Precautions

(i) Take care that the acid does not spill over your clothes
(ii) The battery top should be kept clean
(iii) Use the multimeter in the proper voltage range.
(iv) Do not leave a battery in discharged condition for a long period
(v) Maintain the correct level of acid in the battery
(vi) If the level is low, make it up with distilled water only
(vii) Check the batteries at least once a week

Questions

(i) What is the voltage of a dry cell?
(ii) How many dry cells are packed in a 6V battery?
(iii) What is the voltage of one charged cell of a lead acid battery?
(iv) What is the total voltage of the battery you have observed? How many cells does it have?

(v) What is the material of anode plates?

(vi) What is the material of cathode plates?

(vii) What is an electrolyte?

(viii) What is the voltage of each cell·

a) when it is fresh charged ....

b) when it is discharged ... .

(ix) What do you mean by AH (ampere-hours) in a battery?

(x) What is the specific gravity of the electrolyte in a fully charged cell of a lead acid battery.

(xi) Name the various parts of a lead acid battery.

(xii) What type of battery is used in an automobile and at power station?

(xiii) What type of battery is used in a torch?

(xiv) Explain the chemical reaction during charging and discharging of a lead acid battery.

(xv) What do you understand by the specifications of a lead acid battery? What are the different quantities specified?

ACTIVITY NO. 3

Familiarization with Various Connections of a Rheostat

Specific Objectives

(i) Use of a rheostat as a fixed resistor.
(ii) Use of a rheostat as a variable resistor.
(i) Use of a rheostat as a potential divider

Related Information

A rheostat is a device in which a coil of resistance wire is wound over a tube. It has three terminals. Two ends of the coil are known as fixed terminals. A third terminal is connected to a slider which moves on the resistance coil. This terminal is known as a variable terminal.

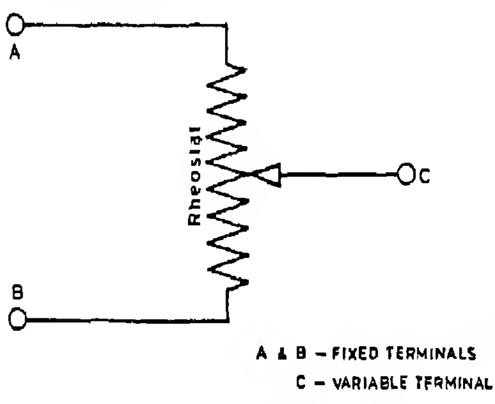


Fig 3 1 Variable Rheostat

The resistance between A and B is always fixed. The resistance between A and C can be varied by varying the position of the slider. Similarly, the resistance between B and C can be varied.

A rheostat can be used as a fixed resistor or fixed load using terminals AB. It can be used as a variable resister/load using terminal AC or BC.

A rheostat can be used as a potential divider to provide variable output voltage from a fixed voltage supply using terminals A, B and C. The output voltage can be varied from zero to maximum value.

Equipment and Materials:

Rheostat 300 ohms, 2A
Multimeter Avometer

Procedure

(a) Rheostat as a fixed resistor

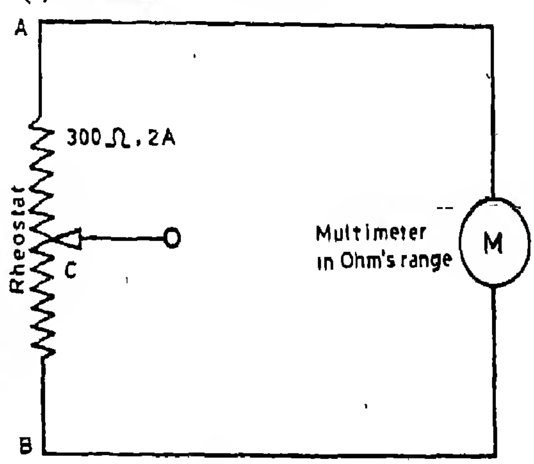


Fig. 3.2 Rheostat connected as a fixed resistance

(i) Cannect the circuit as shown in Fig 3 2 and measure the value of fixed resistance

(ii) Move the slider and measure the resistance across AB (as shown) at different positions of the slider·

Position of Slider.	At B	1/4th BA	1/2 BA	3/4 BA	at A
R (Ohms)					

(b) Rheostat as a variable resistor

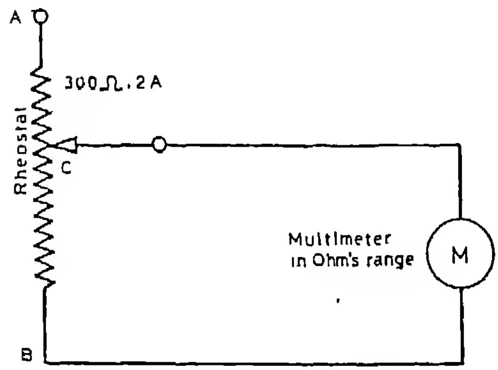


Fig 3 3 Rheostat connected as a variable resistance

(i) connect the circuit as shown in Fig 3 3.

(ii) Bring the variable point (C), at B and measure the resistance.

(iii) Slide the variable point (C) towards A and measure the resistance for different positions.

(iv) Bring the variable point at A and measure the resistance.

(v) Fill in the table:

Position of Slider	At B	1/4th BA	1/2 BA	3/4 BA	at A
R (Ohms)					

(c) Rheostat as a potential divider.

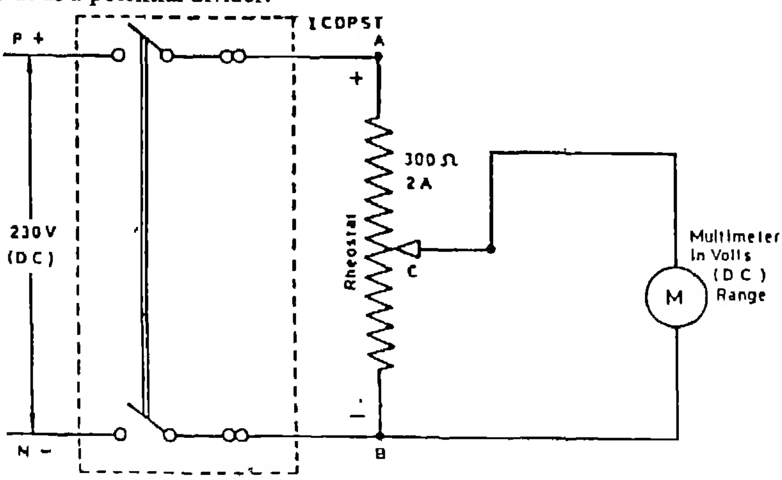


Fig. 3.4 Rheostat connected as a potential divider

(i) Connect the circuit as shown in fig 3 4
(ii) Bring the multimeter in voltage range
(iii) Switch on the supply
(iv) Fill in the table.

Position of Slider	At B	¼ of BA	½ of Ba	¾ of BA	At A
R (ohms)					

Precautions:

(i) When connected in any electrical circuit, the total current flowing through any portion of a rheostat should not exceed its rated current.
(ii) When acting as potential divider, the input voltage should be connected across fixed terminals only.
(iii) Before switching on supply the slider should be adjusted to the minimum output voltage position (in potential dividers)
(iv) Do not forget to change the setting of multimeter from Ohms to voltage range for part (c) of the experiment, i.e , for measuring the voltage output of potential divider
(v) For each application, the rheostat of suitable range (resistance and current) should be used

Questions

(i) What is the significance of current rating of a rheostat?
(ii) What is the value of minimum and maximum resistance of a rheostat as a variable resistor?
(iii) What is the minimum and maximum voltage as a potential divider?

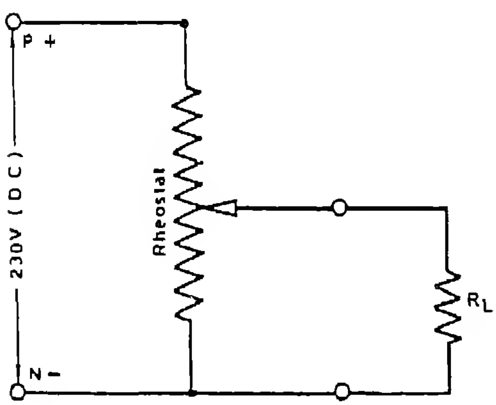


Fig 3.5

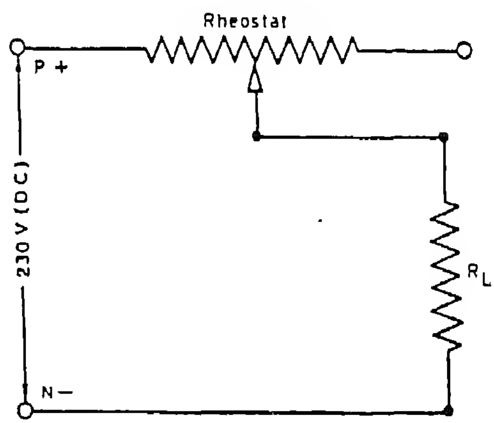


Fig. 3 6

(iv) Discuss the difference between Fig 3.5 and Fig 3 6 to vary the output voltage across RL

ACTIVITY NO. 4

Voltmeter Application for Measurement of Voltage

Specific Objectives

(i) To make a circuit diagram using a voltmeter.

(ii) To connect the voltmeter in the circuit ar ' to measure the voltage.

(iii) To compare the readings of two given voltmeters

Related Information

Voltmeter: A voltmeter is used to measure voltage (pontential difference) It is connected in parallel with the device across which the voltage is to be measured. The unit of voltage is VOLT.

There are two types of commonly used voltmeters The moving coil voltmeter is used to measure DC. voltage whereas the moving iron voltmeter is used to measure both AC and DC voltage

Equipment and Materials

	Range	Quantity
Voltmeter (DC)	0-250-500V	2
Voltmeter (AC)	0-250-500V	2
Rheostat	300Ω, 2A	1
Connecting wires	Flexible wires	

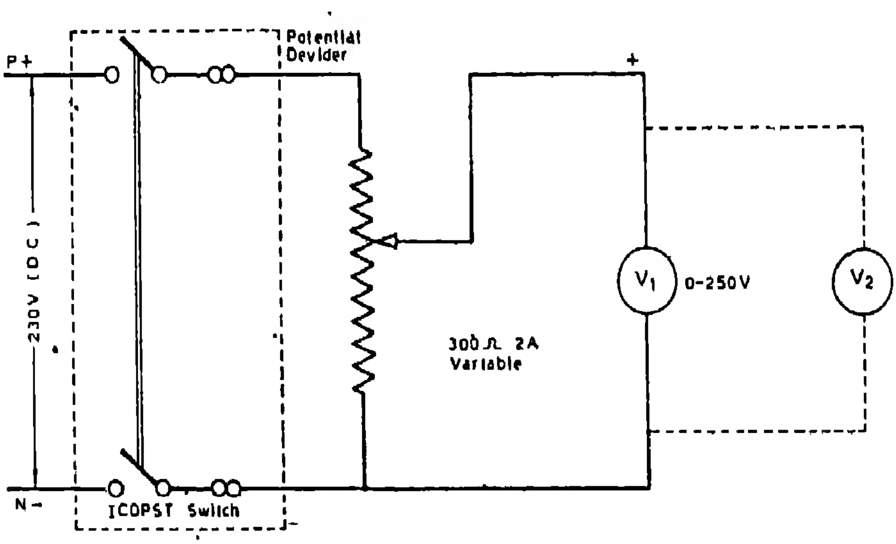


Fig 4.1 Measurement of voltage

Procedure

(i) Make the connection as shown in Fig. 4.1 and check the polarity of the voltmeter.
(ii) Keep the variable point of the rheostat at minimum output voltage position.
(iii) Switch on the supply.
(iv) Adjust the various voltages by potential dividers such as 50, 75, 108, 125, 200V
(v) Read the maximum possible value of the voltage.
(vi) Switch off the supply
(vii) Connect another voltmeter of different range in parallel (as shown dotted)
(viii) Bring the variable point of the rheostat at the initial position
(ix) Switch on the supply
(x) For different position of variable point of potential divider read both the voltmeters and complete the following table.

V_1 volts				
V_2 volts				

(xi) Switch off the DC supply
(xii) Read the supply voltage directly
Supply voltage . . .
(xiii) Repeat steps from (i) to (xii) with AC supply and AC voltmeter
(xiv) Observe the AC supply voltage with AC and DC Voltmeters.
(xv) Read the AC supply voltage with AC and DC meters and note the readings
AC meter . .. . ..
DC meter ....
(xvi) Discuss the results with your teacher

Precautions

(i) Check the polarity in the DC voltmeter.
(ii) Use the DC voltmeter for DC supply and the DC voltmeter for AC supply
(iii) Select the proper scale for the multi-range voltmeter.

Questions

(i) What is the basic function of a voltmeter?
(ii) Is it connected in parallel/series and why?
(iii) What happens when it is connected in series by mistake?
(iv) What happens when it is connected with wrong polarity in DC?
(v) What happens when a DC (permanent magnet moving coil) instrument is connected in AC?
(vi) What happens when an AC (moving iron) instrument is connected in DC?
(vii) What is the voltage of domestic supply?
(viii) Is domestic supply AC or DC?
(xi) What is the frequency of domestic supply?
(x) What is the unit of frequency?
(xi) What is the frequency of DC?
(xii) Looking at the scale how will you differentiate between moving coil and moving iron meters?

ACTIVITY NO. 5

Ammeter Application for Measurement of Current

Specific Objectives

(i) To make a circuit diagram using an ammeter.

(i) To connect an ammeter in a circuit and to measure current

(i) To compare the readings of two given ammeters.

Related Information

An ammeter is used to measure current. It is connected in series with the load in the circuit The unit of current is an AMPERE

There are two types of commonly used ammeters. The moving coil ammeter is used to measure direct current (DC) whereas the moving iron ammeter is used to measure both alternating current (AC) and direct current (DC)

Equipment and Materials

Ammeter (DC) 0-1-2A
Ammeter (AC) 0-1-2A
Rheostat 100Ω, 2A
100Ω, 5A
Connecting wires 3/20 SWG wire

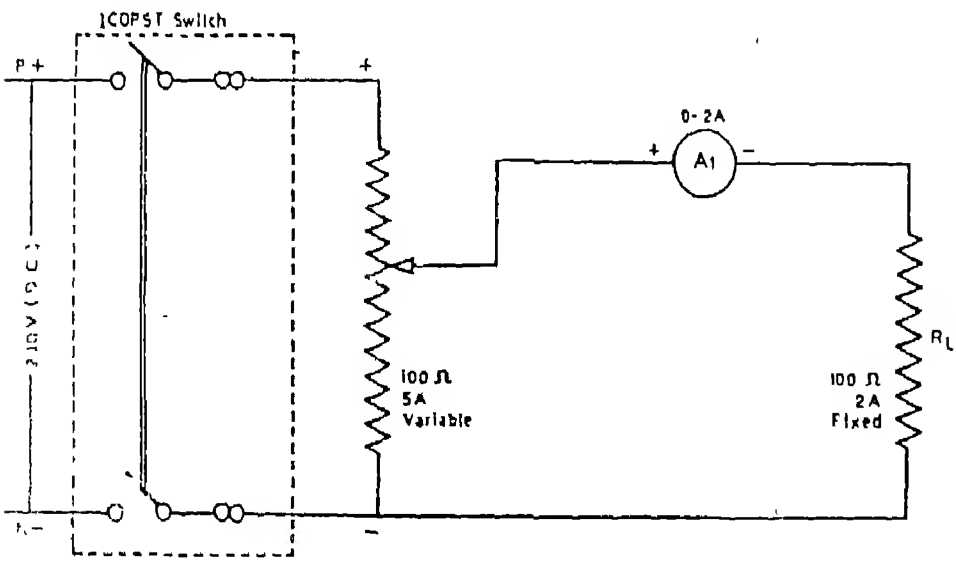


Fig. 5.1 Measurement of current

I C D.P S.T Switch· Iron-clad double-pole single throw switch

Procedure

(i) Make connection as shown in Fig 5.1
(ii) Check the polarity of ammeter A_1
(iii) Keep the variable point of the rheostat at minimum output voltage position
(iv) Keep load resistance at fixed value (maximum)
(v) Switch on the supply
(vi) Adjust the following current by potential divider, 0 5 A, 0.75 A, 1 1 A, 1 5 A.
(vii) Switch off the supply
(viii) Connect another ammeter A_2 in series with ammeter A_1.
(ix) Bring back the variable point of the rheostat at the initial position
(x) Switch on the supply
(xi) For different position of variable point of potential divider read both the ammeters and complete the following table

A1 Amp.						
A2 Amp						

(xii) Switch off DC supply
(xiii) Repeat the complete procedure with AC supply and AC ammeters
(xiv) Complete the following table for AC supply.

A1 Amp.						
A2 Amp						

Tabular Record of Observations:

Meter	Reading in ampere 1	2	3	4	5	6	7
A1							
A2							

Precautions

(i) Use a DC ammeter for DC supply and an AC ammeter for AC supply.
(ii) Check the polarity for DC ammeters
(iii) An ammeter should always be connected in series with the load
(iv) An ammeter should *never* be connected across the supply
(v) Select the proper scale for a multirange ammeter

Questions

(i) What is the basic function of an ammeter?
(ii) Is it connected in parallel/series and why?
(iii) What happens when it is connected with wrong polarity in DC?

(iv) What happens when a DC ammeter is connected in AC?
(v) How do you change the current in the circuit keeping the load resistance fixed?
(vi) How do you change the current in the circuit keeping the voltage fixed?
(vii) Mark the correct answer:

Voltage	Load resistance	Current
Fixed	Less	Less/More
Fixed	More	Less/More
Less	Fixed	Less/More
More	Fixed	Less/More

ACTIVITY NO 6

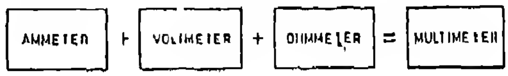
Application of Multimeter

Specific Objectives

(i) Use of multimeter as an ammeter
(ii) Use of multimeter as a voltmeter
(iii) Use of multimeter as an ohm meter.

Related Information

A multimeter combines the features of an ammeter, a voltmeter and an ohmmeter in a single instrument. It is used to measure current, voltage and resistance An AVO meter is also a multimeter in which "A" stands for amperes, "V" for volts and "O" for ohms.



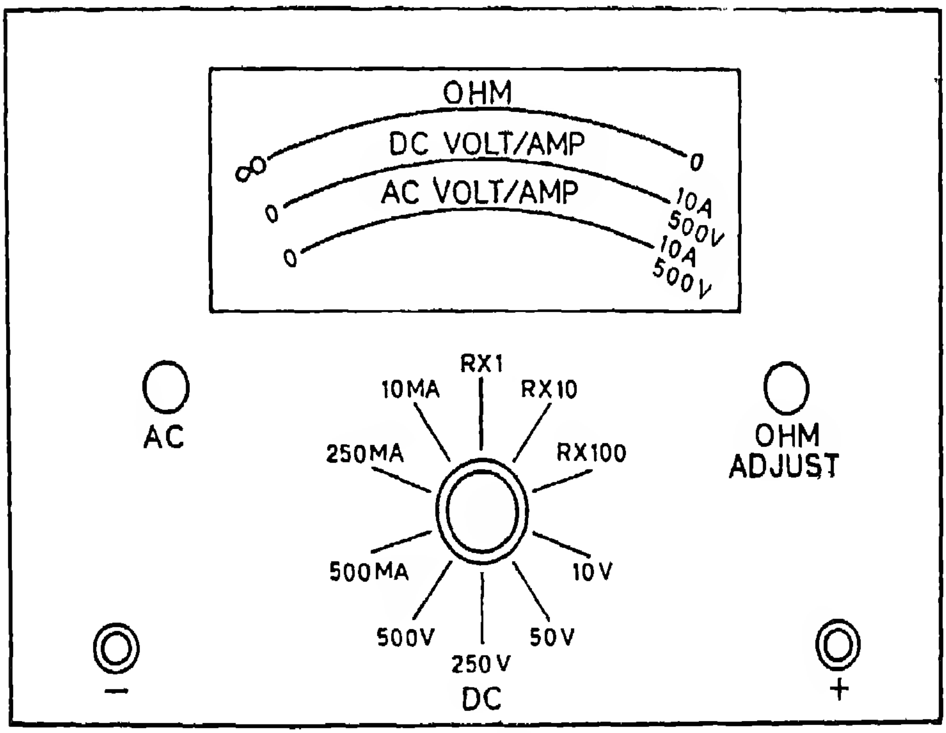


Fig 6 1 Typical Multimeter

usually selects the meter function and the other selects the range.

Equipment AVO meter Procedure

(a) Measurement of DC quantities

(i) Keep AC/DC selector knob on DC

(ii) Select the proper current or voltage range.

(iii) Plug the test leads into the proper jacks.

(iv) Insert the meter in the circuit keeping proper polarity.

(v) Observe the proper scale and record the various readings.

(b) Measurement of AC quantities

(i) Keep AC/DC selector knob on AC.

(ii) Repeat the steps (ii), (iii) and (v) as given above.

(c) Measurement of resistance

(i) Set the meter to read OHMS.

(ii) Plug the test leads into the proper jacks.

(iii) Join the tips of the test probes together, thus, short circuiting the internal circuit (equivalent to inserting ZERO resistance for measurement).

(iv) Turn the OHM ADJUST control until the meter pointer indicates ZERO on the ohms scale.

(v) Touch the two ends of the unknown resistance with test probes of the instrument

(vi) Observe the OHM SCALE and record the reading.

Precautions

(i) Always select the proper range before using the instrument

(ii) Whenever the meter is set for reading OHMS or switched to a new range, short circuit the test probes and set the ZERO pointer with the OHM adjust control.

(iii) Never use an OHM meter to measure resistance in an energized circuit.

(iv) Before using the meter for resistance measurement, ensure that the instrument cells are proper

Questions

(i) What happens when the instrument is used to take resistance reading across the energized circuit?

(ii) Which precaution should be observed while measuring resistance?

(iii) Explain the various functions which a multimeter can perform

(iv) Differentiate between a multimeter and megger

ACTIVITY NO. 7

Wattmeter Application for Measurement of Electrical Power

Specific Objectives

(i) To make a circuit for measuring power using a wattmeter.

(i) To connect a wattmeter and measure power.

(i) To learn about wattmeter constants.

Related Information

Wattmeter: A wattmeter is used to measure the power in an electrical circuit. It has two coils, namely, current coil and pressure-coil (voltage-coil). The current coil is connected in series and the pressure coil in parallel with the load. The unit of power is 'WATT'. In DC circuit power is given by VI watts.

Equipment and Materials

(i) Wattmeter current range 1, 2, 5 Amperes (unity p.f. type) Voltage range 250, 500V — one

(ii) Voltmeter 250V — one

(iii) Ammeter 0-2 amperes — one

(iv) Rheostat 100Ω, 5 amp (centre tap) — one

(v) Rheostat 300Ω, 2 amp (centre tap) — one

(vi) Connecting wire

(a) flexible wires for voltmeters and pressure coil of wattmeter

(b) 3/20 S.W.G. wire.

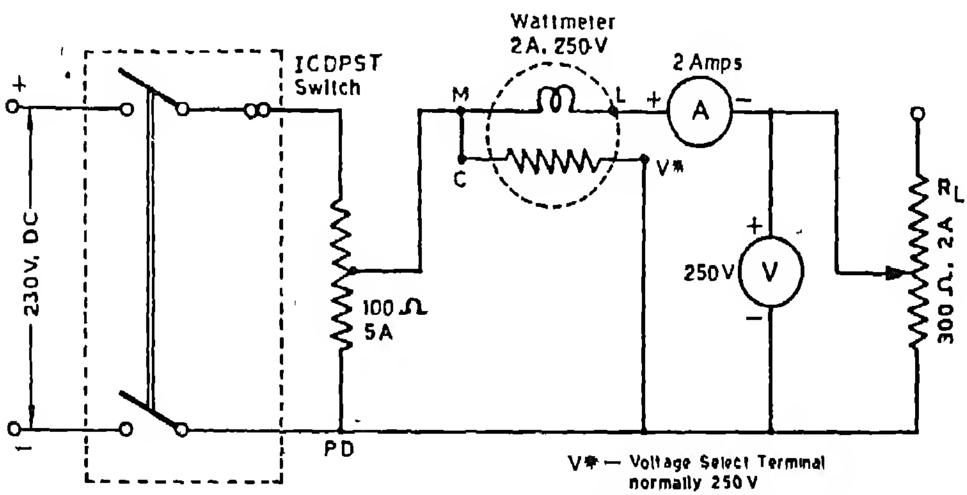


Fig. 7.1 Measurement of Power

Procedure

(i) Cannect the wattmeter as shown in Fig. 7 1.

(ii) Check for polarity of ammeter, voltmeter and connection of current coil (M.L.) and pressure coil (C.V.)

(iii) Keep the setting of "load" rheostat at maximum (i e. maximum resistance) and potential divider output at minimum.

(iv) Switch on the supply.

(v) Vary the output voltage of potential divider (PD) and record the readings of (A, V and wattmeter).

(vi) Keep the (PD) sliding point at maximum and vary the "load" resistance and take the readings of (A, V and wattmeter) DO NOT exceed the current limit while varying load resistance.

(vii) Repeat the experiment (i.e. from 1 to 5) with different settings and ranges of pressure-coil voltages and current coil currents. Do not exceed the range while setting rheostats.

Tabular Record of Observations

Current coil range ....
Pressure coil range ....
Wattmeter constant ....

S No	Ammeter Reading	Voltmeter Reading	Power	Wattmeter reading	Error
	I	(V)	V x I = X	W	W—VI
1					
2					
3					
4					
5					
6					
7.					
8					

Repeat the above table for each range setting.

Precautions:

(i) Identify the current coil and pressure coil terminals.

(ii) The current coil should be connected in series with the load and never in parallel

(iii) Current range selection should be understood and done properly.

(iv) Initially keep the load rheostat in the maximum position.

(v) While adjusting the load resistance, keep an eye on the ammeter to ensure the range of the wattmeter current coil.

Questions

(i) What does this coil ML represent and how should it be connected?

(ii) What does this coil CV* represent and how should it be conncected?

(iii) Fill in the given table: with different combinations of current and voltage ranges.

S No	Current range	Voltage range	Wattmeter constant	Full scale reading
(a)				
(b)				
(c)				

(iv) What is the unit of power?

(v) What is the relationship between voltage, current and power?

(vi) Make diagrams for links for different ranges or current.

ACTIVITY NO 8

Energy Meter Application for Measurement of Energy in Electrical Circuits

Specific Objectives

(i) To make a circuit using an energy meter.

(ii) To connect a single-phase energy meter in the circuit and measure energy.

Related Information

Energy in a circuit is obtained by multiplying power by time. The power (P) in A.C. circuit is given by :

Power = Voltage × current × power factor.

The practical unit is Kilo-Watt-Hour(KWH) Basically, this instrument has two coils similar to the wattmeter (current coil and pressure coil). In addition, there is a rotating disc in place of the deflecting pointer used in a wattmeter.

Equipment and Materials

(i) Single-phase energy meter

(ii) Ammeter 0-5A (a.c.)

(iii) Voltmeter 0-250 V (a.c.)

(iv) Rheostat 100Ω, 5A

(v) Connecting wires:

(a) flexible wire for voltmeter and pressure coil of energy meter.

(b) 3/20 SWG wire

(vi) Stopwatch.

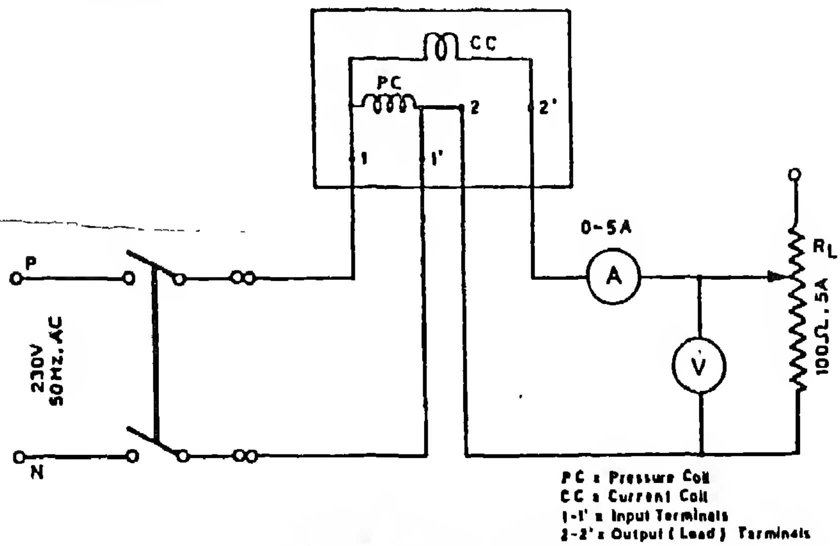


Fig 8.1 Measurement of Energy

Procedure

(i) Make the connections as shown in Fig. 8.1.

(ii) Initially, keep the rheostat at maximum resistance position.

(iii) Switch on the supply.

(iv) Keep the load resistance at a fixed value. Record the voltmeter and ammeter readings

(v) Count the number of revolutions in three minutes.

(vi) Repeat the above procedure for different load currents.

Tabular Record of Observations

(i) Initial reading of energy meter = .. KWH

(ii) Revolution constant of energy meter (K) = .

V Volts	I Ampere	Time T in hour	Energy E_1 in kwh $V \times I \times T$	No of revotntion of energy meter N	E_2= energy consumed KWh. $N \times K$	Difference $E_2 - E_1$

Precautions

(i) A.C. meters should be used.

(ii) Rheostat must be at maximum resistance position initially.

(iii) Current in the ammeter should not exceed its range (i.e. 5 amperes)

(iv) Number of revolutions should be counted carefully.

(v) Input and load terminals should be connected correctly.

Questions

(i) What is the basic function of an energy meter ?

(ii) What is the relationship between energy and power ?

(iii) What will be the effect of load current on the speed of the disc ?

(iv) What is the practical unit of electrical energy ?

(v) If you use a 1000 Watt room heater for 6 hours and the cost of the energy is 50 paise per unit, determine the cost of energy consumed.

Verification of Ohm's Law

Specific Objectives

(i) To prove that the current varies directly as potential difference (voltage) in volts, keeping resistance constant.
(ii) To prove that the current varies inversely as the resistance in ohms, keeping voltage constant

Equipment and Materials

Voltmeter 0-250 V d.c
Ammeter 0-5A d c
Rheostat 220 Ω, 1.5A
Rheostat or Auto variac
250 Ω 1A 250 V/500W
Connecting leads 12 Nos

Related Information

Current, voltage (potential difference) and resistance are interrelated in an electrical circuit. According to Ohm's Law, current in an element of a circuit is directly PROPORTIONAL to the voltage across it in volts and inversely as the resistance of it in ohms, provided the physical conditions remain the same.

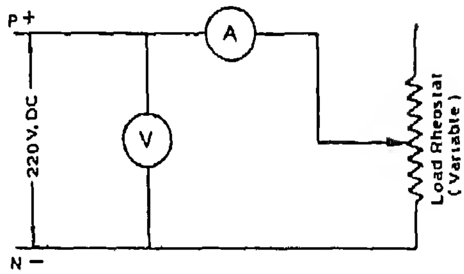


Fig 9 1 Constant Voltage with Load Resistance

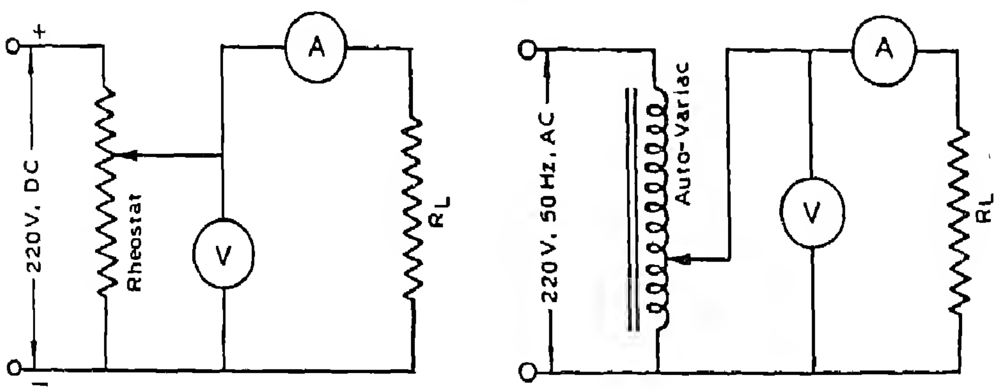


Fig. 9.2 Variable Voltage with Fixed Load Resistant

Procedure

(i) Connect voltmeter, ammeter and load rheostat as shown in the Fig. 9 1; Check the connections. Keep the resistance at maximum value. This is VERY IMPORTANT.

(ii) Put on the D.C supply and record voltmeter and ammeter readings.

(iii) Vary the load step by step and record meter readings. Do not exceed the rating of the ammeter.

(iv) Tabulate the recorded observations.

(v) Connect the circuit as shown in Fig. 9.2 and recheck the connection

(vi) Switch on the supply with fixed load resistance, vary the voltage step by step and record the meter readings

(vii) Tabulate the recorded observations.

(viii) By the tabulated result, it is proved that the current in ampere varies as voltage directly, whereas the current varies inversely as the resistance

S No.	When resistance is veried			When voltage is varied		
	Voltage	Resistance	Current	Voltage	Resstance	Current
1						
2						
3						
4						
5						
6						

Precautions

(i) Do not switch on the supply until connections have been properly made.

(ii) There should be no loose connections.

(iii) Connect voltmeter across supply and load, and the ammeter in series with the circuit.

(iv) Keep the temperature constant, do not overload rheostat.

Questions

(i) How will you connect the voltmeter and ammeter in the circuit ?

(ii) What happens to the resistance and current if the temperature rises ?

ACTIVITY NO. 10

Measurement of Resistance

Specific Objectives

(i) To become familiar with the voltmeter-ammeter method for measuring resistance.

(ii) To plot volt-ampere characteristic of (a) rheostat (b) Incandescent lamp

Related Information

Resistors are available in various types and ratings The voltmeter-ammeter method is a simple method for determining resistance. The volt-ampere characteristic of a linear resistance is a straight line indicating that current is directly proportional to the applied voltage. For non-linear resistance the volt-ampere characteristic is not a straight line

Equipment and Materials

Various type of resistors,

Voltmeter 0-15 V DC,

Voltmeter 0-250 V DC,

Ammeters 0-1A, 0-5A,

Dry cells — 8 in nos.

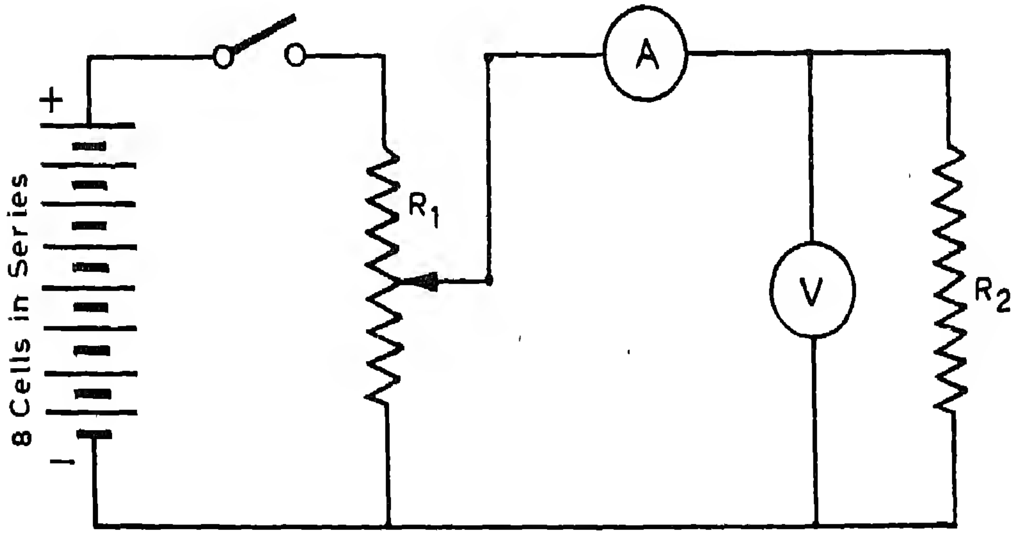


Fig 10 1 Resistant Measurement (Rheostat)

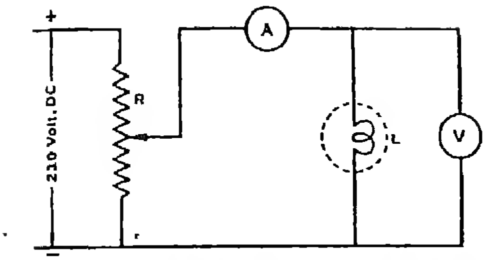


Fig 10.2 **Resistance Measurement (Incandescant Lamp)**

Procedure

(i) Connect ammeter, voltmeter, unknown resistance and a battery as shown in Fig. 10.1

(ii) Adjust the position of the variable point of the rheostat at minimum output voltage.

(iii) Close the key and record the voltmeter and ammeter readings for various positions of the varible point of the rheostat.

(iv) Plot volt-ampere characteristic.

(v) Repeat the same procedure for the incandescent lamp, Fig. 10.2

Tabular Record of Observations

With Rheostat

Voltmeter Readings in Volts (V)	
Ammeter Reading in Amps (I)	
Unknown Resistance of the Lamp $R = \frac{V}{I}$	

With Incandescent Lamp

Voltmeter Readings in Volts (V)	
Ammeter Reading in Amps (I)	
Unknown Resistance of the Lamp $R = \frac{V}{I}$	

Precautions

(i) Make tight connections.
(ii) Connect ammeter and voltmeter suitably

Questions

(i) In what way series or parallel cells are connected to get more voltage ?
(ii) In which case is the value of the resistance practically constant ?
(iii) Is the incandescent lamp a linear or a non-linear device ? Explain why.
(iv) The incandescent lamp obeys Ohm's law True/False

ACTIVITY NO 11

Study of Series Resistance Circuit

Specific Objectives

(i) To become familiar with series lamps and resistor elements.

(ii) To observe voltage and current characteristics in series circuit.

Related Information

In series circuit, the equivalent resistance is the sum of all the resistance connected in the circuit, i e $R_{eq} = R_1 + R_2 + R_3$, etc. While the current through a series circuit is the same at all points, the voltage drop in each element depends upon the resistance of that element i.e. $V_1 = R_1 I$, $V_2 = R_2 I$, etc. The sum of all these voltage drops equals to the applied voltage, i.e

$E = IR_1 + IR_2 + .. = I(R_1 + R_2 + ...)$ in series to boost up the voltage, but if any cell is connected opposite in polarity in between, the voltage is reduced by double the number of cells connected in opposite polarity. For example, if 12 cells of 2 volts each are in series, but two of the cells get connected in opposition to the rest, the total voltage would be 16 volts instead of 24 volts.

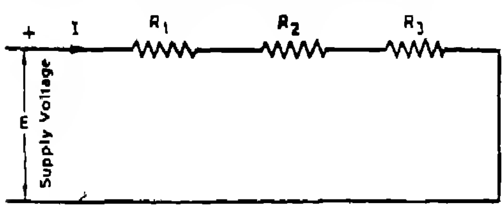


Fig 11 1 Resistances in Series

Equipment and Materials

6V Dry Cells — 10 Nos.
Resistors 5Ω, 10Ω, & 20Ω two each
Ammeter AC/DC 0-5A
Voltmeter DC, 0-30V
Multimeter
Connecting leads

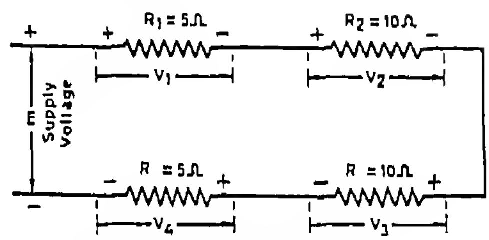


Fig 11 2 Four Resistances in Series

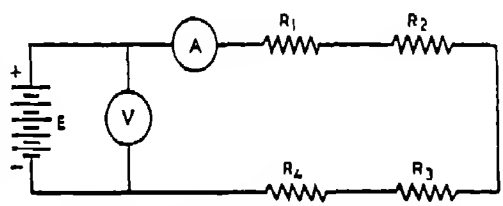


Fig. 11 3 Measurement of Series Resistance

Procedure

(i) Connect resistors as shown in Fig. 11.2 and measure resistance of the whole circuit as well as of each resistor using a multimeter. Record the observations. It shows $R_{eq.} = R_1 + R_2 + R_3 + R_4$

(ii) Connect the circuit as shown in Fig 11.3 with an ammeter in series Record the battery voltage and voltage drop across each resistor using the same voltmeter. Record the ammeter reading.

Results : $E = V_1 + V_2 + V_3 + V_4 + \ldots$

$$Req = \frac{E}{I} = \frac{V_1}{I} + \frac{V_2}{I} + \frac{V_3}{I} + \frac{V_4}{I}$$

Precautions

(i) Connect the voltmeter in parallel and the ammeter in series.

(ii) Ensure that the multimeter has been set to proper range and adjustments before use.

Questions :

(i) What are the properties of a series circuit ?

(ii) Deduce with the help of Ohms Law that in a series circuit $Req = R_1+R_2+R_3$, etc

(iii) Give an example of a series circuit

ACTIVITY NO. 12

Study of Parallel Resistive Circuit

Specific Objectives :

(i) To become familiar with a parallel circuit.

(ii) To study voltage and current characteristics of a parallel circuit.

(iii) To become familiar with the utility of parallel circuit.

Related Information :

In a parallel circuit, the equivalent resistance is less than the resistance of any branch in the circuit. In this circuit, the current is divided in the branch circuits while voltage across various branches of the circuit remains equal to the applied voltage Parallel circuits are used for domestic and industrial electrical installations so as to maintain constant voltage at each machine and/or lamps In a parallel circuit, total resistance RT is given by $\frac{1}{R_T} = \frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$ where R_1, R_2, R_3 are resistance in parallel branches

Equipment and Materials :

Lamp 40W/250V, 60W/250V, 100W/250V — one each
Rheostats — three in nos.
Voltmeter 0-30 Volts — three
Ammeter 0-1A — three
Ammeter 0-5A — one
ICDP Switch — two
Single Pole Switch — Six
Connecting Wire

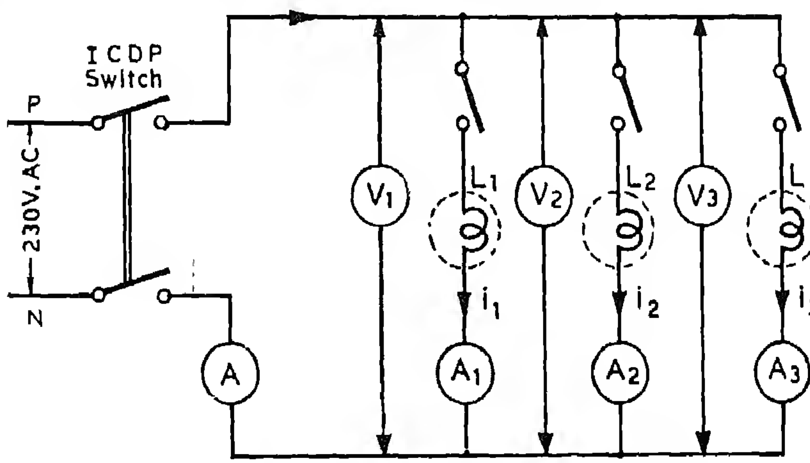


Fig 12.1 Measurement of Parallel Resistance (Lamps)

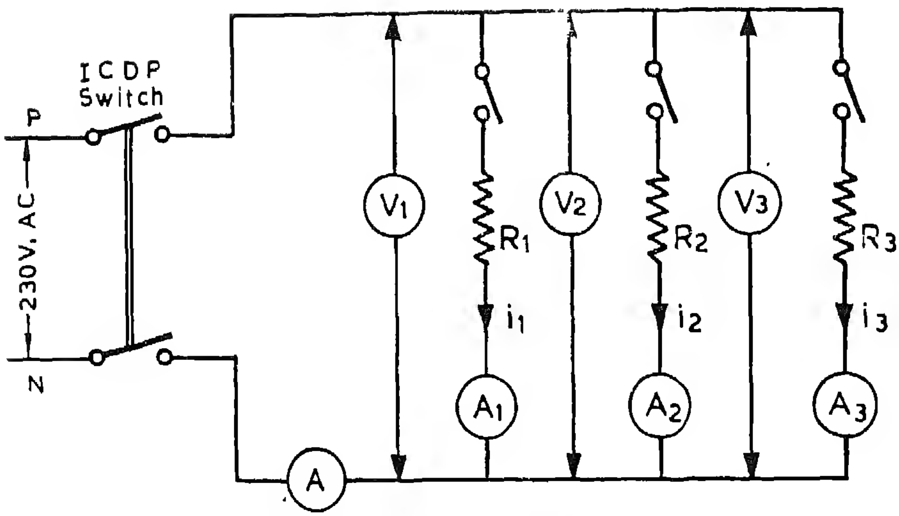


Fig 12.2 Measurement of Parallel Resistance (Rheo stat)

Procedure

(i) Connect lamps in parallel as shown in Fig 12.1 through their individual switches and ammeters. Switch on the mains and individual switches one by one Record ammeter readings of each branch and of the whole circuit Record the circuit voltage

Results $E = V_1 = V_2 = V_3$ and $I = i_1 + i_2 + i_3$
Resistance of each lamp = Voltage across each lamp/Current of each lamp
Power consumed by each lamp = Current through each lamp×Voltage across each lamp.

(ii) Repeat procedure (i) using rheostat in place of lamps The supply voltage $E=V_1=V_2=V_3$. V_1, V_2, V_3, are the voltages across each rheostat I is the total current and $I=i_1+i_2+i_3$
Resistance of each rheostat = Voltage across each Rheostat/Current of each Rheostat
Equivalent Resistance Req. = V/I
Power consumed by each resistor = Voltage across each resistor × Current through each resistor

Tabular Record of Observations

Particulars	Lamps			Resistors		
	L_1	L_2	L_3	R_1	R_2	R_3
Current (amps)						
Voltage (Volts)						
Power (Watts)						
Resistance (Ohms)						

Procautions

(i) Connect ammeter in series and voltmeter in parallel.

(ii) Do not touch or hold hot lamps/resistors.

Questions

1. What are the advantages of a parallel domestic wiring ?
2. Where will you use a parallel circuit ? Why ?
3. In your experiment if one of the lamps is fused what will be the effect on the (a) total current,(b) current of the other branches ?
4. Show that for a parallel circuit, total effective resistance is given by .

$$\frac{1}{Req} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \quad \text{etc}$$

ACTIVITY NO. 13

Study of Conductors and Insulators Measurement of Their Resistances

Specific Objective

(i) To become familar with various types of conductors and insulators.

(ii) To learn to measure the reistance of a conductor.

(iii) To become familiar with the operation of a megger.

(iv) To use a megger for insulating tests.

Related Information :

Copper and aluminium conductors are used for domestic and industrial wiring installations. Silver is the best conductor of electricity, but for practical purposes, copper is the best conductor of electricity. Due to economic considerations, aluminium has almost replaced copper as the conductor in overhead transmission lines, cables and wires. Insulating materials are glass, porcelein, plastic, P.V.C., asbestos, rubber, varnish, mineral oils, silk, wool, etc. Poly-venile chloride compounds (P V C) are nowadays mostly used for insulating wires, stranded cables, supports and coverings Resistance is measued by ohmmeters, wheatstone bridge, and voltmeter-ammeter method, whereas insulation of lines, machines is measured by the insulation tester, the megger A megger is a combination of a hand driven D.C. generator and an ohmmeter in one case It is a true ohmmeter having pressure coil, current coil and the pointer attached to each other so as to move the pointer between zero and infinity in megohms

Equipment and Materials

Megger 500 V, one
D C. Voltmeter 0-7 5V one
D.C Ammeter 0-1 Amp — one
Dry cells — 4 Nos

Wires and cables coils of 100 mtrs — 2 Nos

Display boards of wires and cables and insulating materials

Rheostat 10 ohms/2 Amps — one Wire leads 6 Nos.

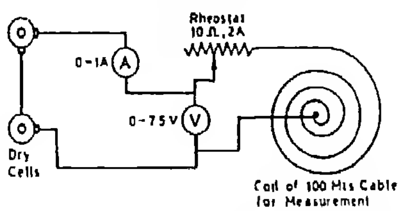


Fig. 13.1 Measurement of Cable Resistance

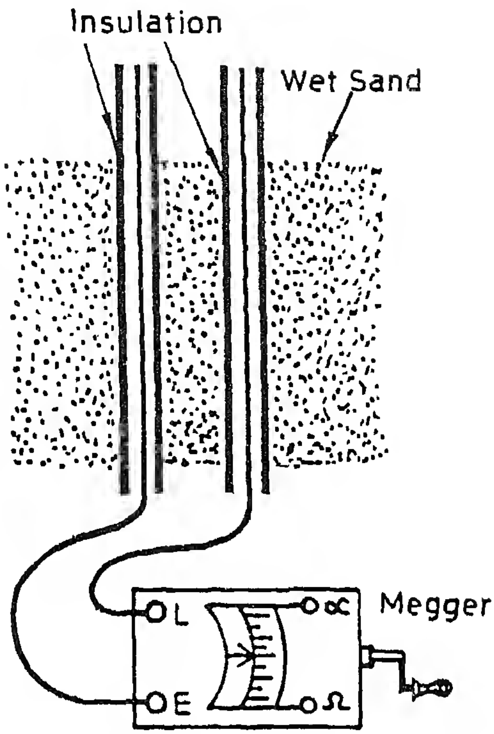


Fig. 13 2 Measurement of Insulation Resistance

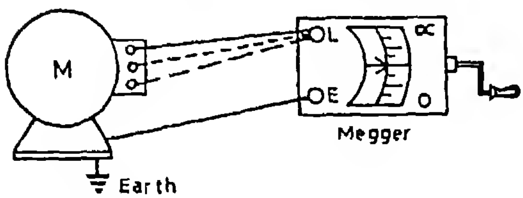


Fig. 13.3 Measurement of Insulation Resistance of Electrical machine

Procedure

(i) Take out display board of various wires and cables. Study and measure the gauge number of each wire and cable. Record name, data, gauge number, type, current capacity of each wire and cable.

(ii) Take out display board containing all sorts of insulating materials — observe and record. Find out its dielectric strength using an electricians' handbook and/or manufacturers data-tables.

(iii) For measurement of resistance of wire/cable coil, make connections as shows in Fig 13.1 Control the current by using rheostat so that volt-ammeter readings are clear and near to full scale deflection. Observe and record the readings.

$$\text{Resistance of the coil} = \frac{\text{Applied voltage}}{\text{Current flowing}} = \frac{V}{I} = R \text{ (ohms)}$$

(iv) Connect L and E terminals of the megger to the pairs of long wires (insulated) dipped in wet sand as shown in Fig 13.2 Rotate the handle of the megger and observe the megger scale The pointer will be steady on the scale according to the stength of the insulation If it shows infinity the insulation is 'excellent', if it show 'high megohms', it is good and if it shows below one megohm, it is 'poor' and needs replacement

(v) Connect L and E terminals of the megger to the electrical machine (AC/DC motor, generator, control gear, domestic appratus, etc.) as shown in the Fig. 13 3 E of the magger to the 'good earth' and 'L' of the megger to any one of the machine/equipment terminal one by one Rotate the handle of the megger, observe and record readings If it shows infinity, the insulation of the machine/equipment is 'the best'. If the megger pointer indicates high megohms it is 'good' and if it indicates below 1 megohm (half megohms in wet atmospheric conditions) it is 'poor', and the insulation in the machine needs replacement.

Tabular Record of Observations

Record your observations of the last three stages of the experiment.

Precautions

(i) Do not connect the megger on a live line.

(ii) Carry out the experiments as per steps only

(iii) Do not keep the cells connected for a longer time, or they may get damaged

(iv) A megger is a very delicate and costly instrument — do not handle it roughly Follow the manufacturers instructions.

Questions

(i) Which is the simple and easier method of measuring resistance of wires and cables ?

(ii) Name the types, sizes of wires and cables that you know

(iii) Why are the P V C. insulated cables most popular nowadays ?

(iv) How can the insulation resistance of an electric machine be measured ?

(v) As per ISI code, leakage permissible in the electrical installation is five thousandth part of load power or current.

(True/False)

ACTIVITY NO. 14

Construction of Electromagnet

Specific Objectives

(i) To become familiar with various types of electromagnets.
(ii) To prepare laminated iron core for an electromagnet
(iii) To acquire skill in winding enamelled wire on the core to prepare an electromagnet.
(iv) To learn to test an electromagnet for resistance and magnetic strength

Related Information

Electric bells, industrial electromagnetic pullers, under-voltage and over-current protection relays use electromagnets. Basicaly, electric motors, generators, fans, industrial and power station relays function on electromagnetism. Therefore, it is necessary to learn about and acquire skill in making electromagnets which will be useful for the repairs and maintenance of relays, bells and machines etc.

Equipment and Materials

(i) H or E or U shaped iron laminations — 20 pieces of any available size
(ii) Super enamelled winding wire - 20G, 22G, 26G, or 28G as available
(iii) Butter paper or thin plastic paper sheet — small sheet
(iv) Former for preparing coil
(v) Testing set-up and tools
(vi) P.V.C. adhesive tape
(vii) Ammeter DC 0-1 Ampere.

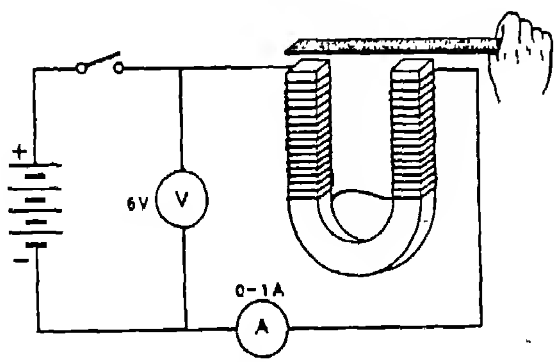


Fig. 14 1 U-Slaped Electromagnet

Procedure

(i) Collect wooden former/leatheroid/plastic/butter paper, super enamelled wire Set the paper on former

(ii) Start winding enamelled wire for a given size of core. Prepare coil of given number of turns and complete the coil.

(iii) Measure resistance of prepared coil using battery — volt-ammeter method and record the resistance

(iv) Fix the coil on the laminated iron core of given size.

(v) Insulate perfectly with coil leads taken out, use P V.C. adhesive tape for top covering.

(vi) Connect coil ends to the DC source with ammeter in series as shown in Fig 14.1

(vii) Observe and record the current flow. The force of electro-magnetic pull can be realized by the attraction of a hack-saw blade held upon the top of core, at a little distance from it. The mmf./magnetic strength is proportional to the 'ampere-turns'

(viii) Switch-off the supply and disconnect the circuit.

Tabular Record of Observations

VOLTAGE	CURRENT	RESISTANCE	TURNS	AMP TURN

Precautions

(i) Do not keep the enamelled wire loose.

(ii) Pay attention towards specified data of resistance and core size.

(iii) Do not undersize or oversize the coil, so that it is neither fit not too loose on the core.

(iv) Keep the perfect insulation between layers of coil and on the top.

Questions :

(i) How will you determine number of turns, wire size and the dimension of the core

(ii) What precautions will you observe while winding a coil?

(iii) What is the method of taping insulation on the coil ?

(iv) How much voltage will you apply for testing a coil ?

ACTIVITY NO. 15

Making of a Simple Electric Bell

Specific Objectives

(i) To become familiar with various types of bells

(ii) To acquire skill in making an electric bell

(iii) To connect and test an electric bell.

Related Information :

Electric bells employ electromagnets There are various types of electric bells, such as single stroke bell, DC bell, AC bell, vibrating stroke bell, buzzer, chime, etc A bell has a gong, while a buzzer does not have a gong The electric chime has a sound box, resonated sound strips of iron/brass and plunger An electric bell gives a harsh sound, while the chime (single or two tone) gives delightful call signal strokes Making an electric bell of either type, is useful and interesting

Equipment and Materials :

(i) Electrician tools box—one

(ii) Super enamelled wire — 100 gm

(iii) E/U shaped laminations—20 pieces

(iv) Leatheroid/plastic paper 2 mm — 120 cm^2

(v) Testing set-up

(vi) Iron strips — 1 cm × 10 cms

(vii) Bell gong with screws and nails — one

(viii) Wooden block 15 cm × 10 cm — 2 nos

(ix) Multimeter — one

(x) P.V C. insulation tape

(xi) Connecting wire

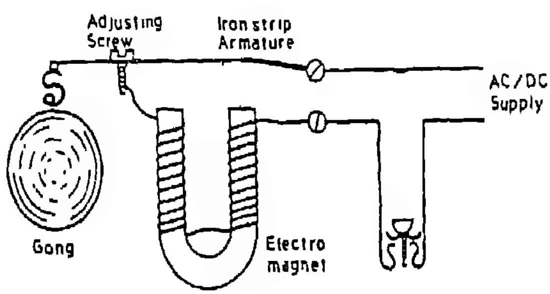


Fig. 15 1 Electric Bell

Procedure :

(i) Collect the required material such as former, cores/u-core, iron-strip armature, adjusting screw, enamelled wire, gong, etc.

(ii) Wind up coils of enamelled wire as per given data

(iii) Fix up coils on core on wooden block, fix up iron armature and the gong as shown in Fig 15.1. Insulate perfectly.

(iv) Measure resistance by a multimeter Connect the bell to the appropriate supply according to the given data.

(v) Test bell and adjust sound.

(vi) Observe and study demonstration boards of various types of bells and chimes. Draw their respective diagrams

Type of bell	DC bell	AC bell	Vibrating bell	Buzzer	Single tone chime	Double tone chime
Rated voltage						
Rated power						
Mode of sound						

Precautions

(i) Select and use proper size of wire and core

(ii) Wind the coils neatly. Do not overlap the wires.

(iii) Fix gong, core, strip armature in correct position

(iv) Do not apply excessive voltage.

(v) Adjust sound properly.

Questions

(i) What size of wire is used to wind the electromagnet of a bell ?

(ii) The winding wire used is ___ (P V C wire/D.C.C./Super enamelled).

(iii) A U-shaped core is made of ______ (carbon steel/silicon steel alloy).

(iv) Briefly explain the working of the vibrating type electric bell.

(v) A double tone chime has _____ push buttons to control the circuit

(vi) What is the purpose of adjusting screw in a vibrating bell?

ACTIVITY NO 16

Study of Various Parts of a DC Machine

Specific Objectives

(i) Study of armature and field circuit.
(ii) Study of commutator and brush gear.
(iii) Study of the magnetic circuit of a DC machine.
(iv) Study of the rating of a given machine.

Related Information

A DC machine essentially has the following parts :

(i) Field system
(ii) Armature core and windings
(iii) Commutator
(iv) Brush gear

Field System

The field system of a DC machine is made up of the following parts :

(a) Yoke : The frame of a DC machine is used as a yoke to complete the magnetic circuit.
(b) Pole body and Shoe . The poles which consist of two parts, the pole body and the pole shoe, are generally bolted onto the yoke.
(c) The poles are excited by a winding placed over the pole body, called the exciting or field winding The number of turns and cross-section of the field winding depending upon whether the machine is to be operated as a shunt, series or compound machine. The shunt field is connected in parallel with the armature and the field coils consist of a

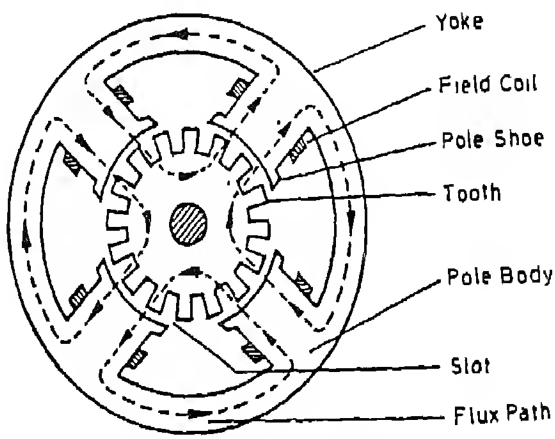


Fig. 16 1 D C Machine Field System

large number of turns of a small cross-section The resistance of the shunt field winding is comparatively high and it draws a small current. The series field winding, which is normally connected in series with the armature, has to carry the load current and consists of a small number of turns of large cross-section. In a compound wound machine, both shunt and series windings are present The electrical connections of the armature and the exciting windings are shown in Fig 16.2 Armature terminals A1 and A2 are physically connected through armature coils so as to allow armature current to flow through the armature

Armature : The armature core is made of sheet steel laminations It carries the conductors in slots punched in the laminations and completes the magnetic circuits. The armature-winding consists of a large number of coils, each coil being made up of one or more turns

Commutator : The commutator is made of hard drawn, wedge-shaped copper segments insulated from each other by thin mica layers. The ends of the commutator segments facing the armature are projected, forming a riser to which the connections from the armature conductors are soldered.

Brush Gear : The brushes are held in position by box type brush holders attached to the stator frame. The brush pressure on the commutator is adjustable through a small spring provided at the back of the brushes. The current collected by the brushes is delivered to the external circuit by flexible copper pig tails fixed to the brushes.

Rating : Every DC machine, whether it is a motor or generator, has a voltage current and power (product of voltage and current) rating. This is usually specified on the nameplate of the machine.

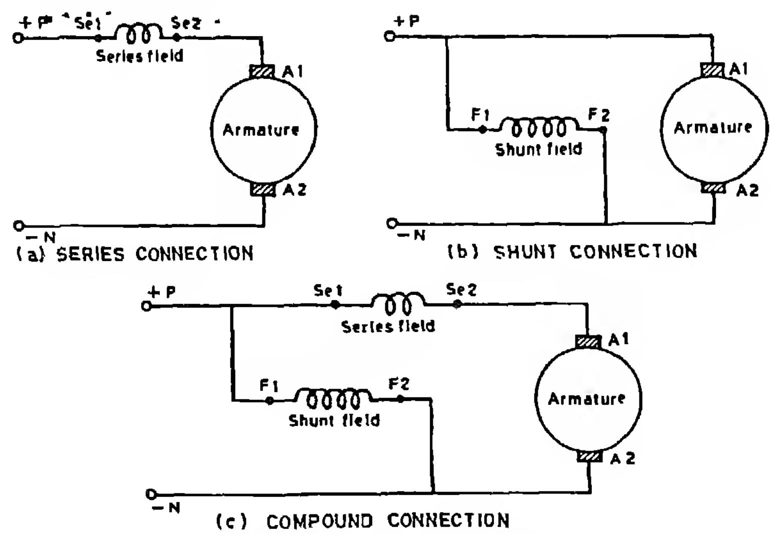


Fig. 16.2 Armature and Exciting Winding Connections

Equipment and Materials

(i) DC Series, motor/generator
(ii) DC shunt motor/generator
(iii) DC compound motor/generator
(iv) Electrician's hand tools
(v) Multimeter
(vi) Megger.

Procedure

(i) Remove the end covers of the given DC machine. Locate the yoke, pole body, pole shoe and the exciting winding.
(ii) Locate the armature winding, armature slots and teeth.
(iii) Locate the commutator of the machine and count the number of commutator segments.
(iv) Locate the brush gear fitted on the commutator. Take out the carbon brushes and note how they are held in contact with commutator segments by the springs.
(v) Count the number of poles for which the field circuit is designed.
(vi) Draw a neat sketch of the field circuit, pole body, pole shoe, commutator segment, armature and brushes.
(vii) Observe the insulation on the field winding and armature winding.
(viii) Measure the resistance of the field and armature windings.
(ix) Measure the insulation strength of field and armature winding.

Precautions

(i) Before you open the end covers of the machine, make sure that the machine is disconnected from the mains.
(ii) While you are studying various parts of the machine, make sure that the machine remains disconnected from the mains.

Questions

(i) What materials is used for armature and field windings ?
(ii) Is the machine a motor or generator ?
(iii) If the machine is a motor, can it be driven as a generator or vice versa ?
(iv) What will happen if no insulation is used on the armature of field windings ?
(v) The conductor cross-section for a series field winding is thicker as compared to the cross-section for a shunt field winding. Is this statement true ? If yes, give reasons in support of your answer.
(vi) What is the practical utility of a DC generator ?
(vii) What are the practical applications of a DC motor ?
(viii) Is the dynamo used in a bicycle a generator or motor ?
(ix) Plot the waveform (w.r.t. time) of the voltage generated by a DC generator.
(x) In the given machine, do you observe some additional poles between the main poles ? What are these poles called and what is their purpose ?
(xi) Locate the bearings of the machine.
(xii) How many leads are coming out as terminals of the machine ?
(xiii) What is the magnitude of the voltage between the output terminals ?
(xiv) What is the current rating of the armature and field windings ?
(xv) Is there a difference between the cross sections of the armature and field windings ?
(xvi) Is the machine connected to supply mains through a switch ? If so, what type of switch is it ? What is the rating of this switch.

ACTIVITY NO 17

Study of DC Shunt Motor Starter

Specific Objective

Study of a given DC shunt motor starter.

Related Information

Shunt Motor Starter

When the armature of a DC machine rotates, an emf is induced in the armature conductors. If the emf is less than the terminal voltage of the armature connected to a supply system, the machine runs as a motor, drawing electric power from the supply and converting it to mechanical energy

The voltage equation for a DC motor can be written as .

$V_a = E + I_a R_a$ (i)

$I_a = \frac{V_a}{R_a}$ ... (ii)

E = terminal voltage

V_a = e.m.f. generated in armature

I_a = armature current

R_a = armature resistance

Since, the armature resistance R_a is low, the motor will draw a heavy current from the mains, of switched on directly across the supply

To limit the starting current, a starter is used which reduces the voltage applied to the armature during the starting period

A starter is essentially a variable resistor of suitable current carrying capacity inserted in the armature circuit to decrease the current drawn by the motor at starting.

When the motor speeds up, the back emf develops to oppose the applied voltage and the starter resistance is cut out in suitable steps.

The circuit diagram of a three-point starter is shown in Fig 17 1. There are three terminals usually marked L,A and F as shown. The starting resistance is connected between the studs 1 and 5. The connection to the starter resistor is made through a moveable contact, fitted to handle capable of sliding over the studs The field of the motor is supplied through the starter terminal marked F as shown in circuit. The positive of the supply lines is connected to the L terminal of the starter and the negative to the armature and field of the motor As soon as the handle moves on to stud number 1, the armature as well as the field circuit of the motor get connected to the supply and the motor starts rotating. When the motor has picked up speed, the handle is moved to stud 2, cutting off the resistance between studs. 1 and 2. Likewise, all the resistance is slowly cut out, when the motor comes to full speed and the handle is in contact with stud '5' marked 'ON'. To hold the handle in the same position when the motor

is running, an electromagnet or a holding magnet or a No-volt Release Coil (not shown in the figure) is used

The total current drawn by the motor passes through the winding of a small electromagnet (not shown in the figure) known as overload release. In the event of an overload, the starter handle swings back to 'OFF' position with the help of the overload release.

Equipment and Materials

(i) DC shunt motor (1 H.P.)
(ii) DC shunt motor starter
(iii) Electrician's Tool Kit
(iv) Multimeter
(v) Magger

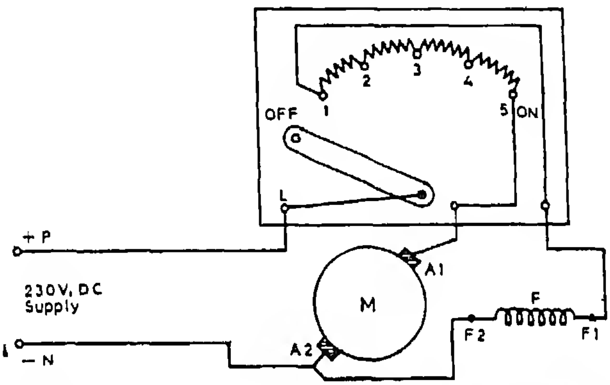


Fig 17 1 D C Motor Starter with No-volt and over volt release

Procedure

Study the following parts of a shunt motor starter.

(i) Starting resistances connected between the studs of the starter.

(ii) Starter handle

(iii) No volt coil.

(iv) Overload coil

(v) Three terminals L, A and F of the starter.

(vi) Move the handle from the OFF position to the last stud, i e the ON position and observe the effect of the spring in bringing the handle back to the OFF position

(vii) Trace the connections of No-volt and Overload coils and redraw Fig 17 1 with these coils included in the starter circuit

(viii) Measure the resistance of No-volt and overload coils.

Tabular Record of Observations

Shunt Motor Starter

Measure the value of resistance inserted in the armature circuit when the handle touches stud 1,2 .5 Make use of an accurate resistance measuring instrument

Tabulate the results

S. No	Stud No	Value of resistance inserted in the armature
i.		
ii.		
iii		
iv		
v		

Questions :

(i) Why starters are used with motors for startings?

(ii) Draw circuit diagram of a D.C. shunt motor starter.

ACTIVITY NO. 18

Running and Reversing of a Shunt Motor

Specific Objectives

(i) To connect a DC shunt motor to supply through a starter
(ii) To start and run the motor
(iii) To run the motor in reverse direction

Related Information

In order to run and operate a DC shunt motor it is connected to the mains through a starter as shown in Fig 18.1. On starting, it picks up speed and runs in the normal direction.

In order to reverse the direction of the rotation of the motor, either the direction of current through field winding or the armature of the motor is reversed. If the currents through both field winding and armature are reversed, the direction of rotation does not change

Equipment and Materials

(i) DC shunt motor
(ii) Three point starters
(iii) Electrician Hand tools
(iv) Tachometer
(v) Connecting leads

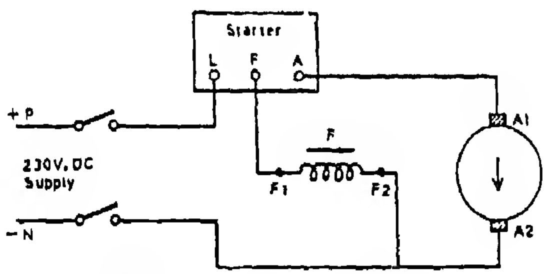


Fig. 18 1. D C. Shunt motor rotation

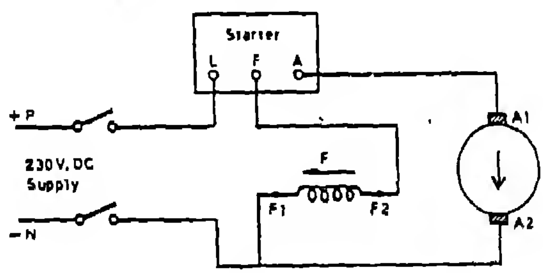


Fig 18 2 D.C. Shunt motor rotation reversal

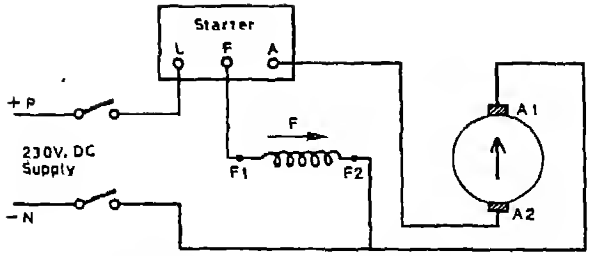


Fig 18.3 D.C. Shunt motor rotation reversal

Procedure

A. Running of Motor

(i) Connect the motor as shown in Fig. 18 1

(ii) Switch on the supply mains

(iii) Move the starter handle to first stud. Wait for some seconds and then move the handle to the next stud. Once again, give a pause and move the handle. Follow this procedure at all steps of the starter

(vi) Measure the speed and note the direction of the rotation.

(v) Stop the motor by switching off the main switch. Never pull back the starter handle to stop the motor.

B. To run the motor in reverse direction

(i) Connect the motor as shown in Fig. 18.2.

(ii) Switch on the supply and start the motor as in stop (iii) above.

(iii) Measure the speed and note the direction of rotation.

(iv) Stop the motor.

(v) Reconnect the motor as shown in Fig 18 3.

(vi) Start and run the motor. Measure the speed and note the direction of rotation.

S No	F ·ld Connection	Armative Connection	Direction of Rotation Clockwise or anti-Clockwise	Speed
1.	$F_1 \rightarrow F_2$	$A_1 \rightarrow A_2$		
2	$F_2 \rightarrow F_1$	$A_1 \rightarrow A_2$		
3	$F_1 \rightarrow F_2$	$A_2 \rightarrow A_1$		
4.	$F_2 \rightarrow F_1$	$A_2 \rightarrow A_1$		

Precautions

(i) To run the motor, move the starter handle slowly from the OFF to the ON position, giving a suitable pause at each step. Do not pause too long at any step.

(ii) Never pull the starter handle to stop the motor.

Questions :

(i) Why do we use a starter to start a motor ? Why is it not switched on directly to the mains ?

(ii) Why should the starter be allowed to rest at each step for a few seconds ? What will happen if the starter is pulled from the OFF position to the ON position in one stroke ?

(iii) Why should the starter handle not be pulled back to stop the motor ?

(iv) On reversing either the direction of field current or armature current, why does the direction of rotation of the motor reverse ?

(v) What will be the direction of rotation of the motor if both field current and armative current directions are reversed ?

To Study a DC Series Motor Controller

Specific Objectives

(i) To study a series motor controller
(ii) To draw the controller circuit diagram

Related Information

A DC series controller performs the functions of starting, speed control and reversing of the motor In a series motor, armature, field winding and starting resistance are all in series The starting resistance, if re-introduced in the circuit after the motor has picked up speed, reduces the speed of the motor and the speed may be controlled. A schematic diagram of the controller connection for series motor is shown in Fig 19.1. The controller is in the form of a drum formed by a number of copper contact rings around iron spiders clamped to a steel shaft. On rotating the drum by a handle, the rings come into contact with copper strips known as fingers mounted on a fixed shaft The fingers are arranged in a vertical line. The contact rings are so shaped that each one of them engages with the finger opposite to it when the control handle is in the appropriate position.

There are two sets of contacts on the drum One set marked 'a' to 'k' is in circuit when the motor is required to run in a forward direction, while the set of contacts marked 'a' to 'k' is engaged when the motor is to be reversed When the controller is in the OFF position, none of the fingers make contact with the drum. On rotating the drum to the forward position 1, the motor starts up The current flows from the positive line to finger A through a blow out coil (which is a protective device), contact a, contact b, finger B, all the control resistors, motor field to H, contact h contact i, finger I, armature, finger K, contact k, contact j, finger J to the negative line.

In the control position 2, the current flows from positive line to finger A, contacts a, b and c, finger C and then as above. Thus the first section of control resistor is cut out and the motor accelerates. The procedure is continued till the controller is in position 6 wherein the current flows from the positive line to contacts a,b,c,d,e,f, and g, finger G, motor and back to the negative line No control resistance is left in the circuit

On the reverse position, connections between contacts h′, i′, j′ and k′ are different from the corresponding forward positions. Therefore, when the controller is in the reverse position 1, current from the positive line to finger A, contract a′ and b′, finger B, all the control resistors, motor field, finger H as before, contact h′, k′ finger K, armature, finger I, contacts i′ and j′, finger J and the negative line. The direction of the current

through the field winding is unchanged but the armature current is in the opposite direction, thereby, reversing the direction of rotation.

Equipment and Materials

(i) Drum controller
(ii) Series Motor
(iii) Multimeter
(iv) Electrician Tool kit
(v) Connecting wires and cables

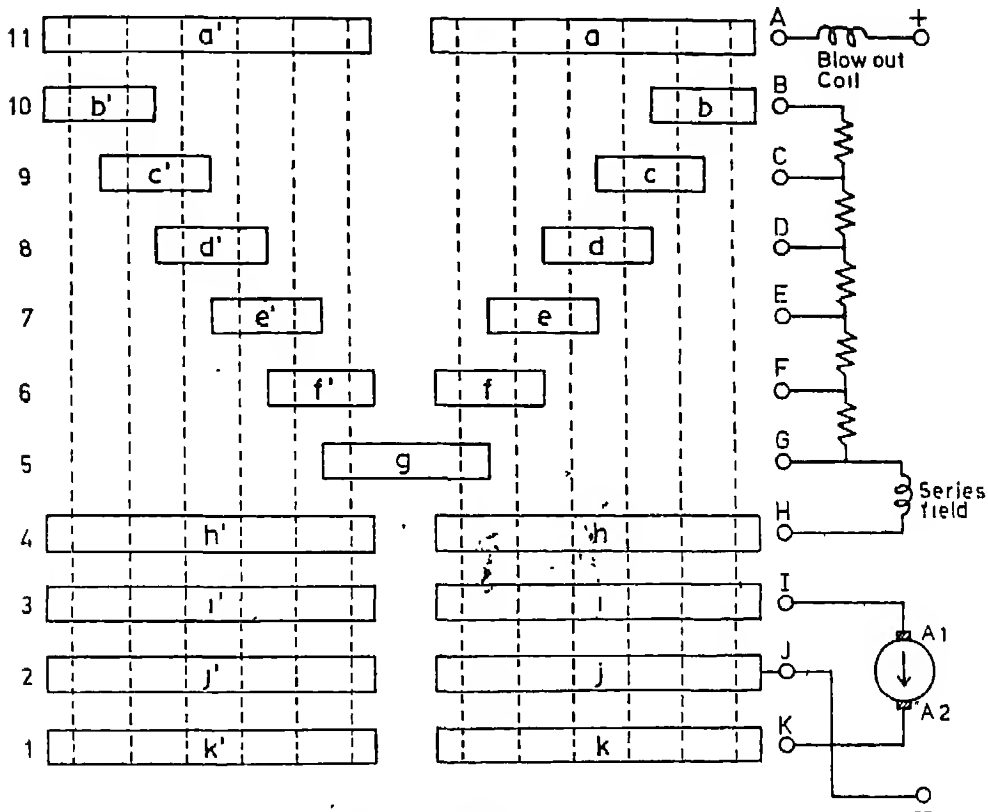


Fig 19 1 Series motor controller

Procedure

(i) Open the cover of the controller.

(ii) Trace the electrical circuit at each of the steps in both forward and backward directions with the help of the multimeter.

(iii) Draw a neat diagram.

Tabular Record of Observations

(i) Record the resistance in the motor circuit at each step.

(ii) Show the connections and path of the current for each step of control.

Precautions

Ensure that the controller is not connected to electric supply

Questions

(i) What are the functions of a series motor controller ?

(ii) How is the controller different from a DC shunt motor starter ?

(iii) Where is a controller used in practice ?

ACTIVITY NO. 20

Speed Control of a DC Shunt Motor

Specific Objectives

(i) Speed control of a DC motor by varying the field current (field control)

(ii) Speed control of a DC motor by inserting external resistance in the armature circuit (rheostatic control)

Related Information

The speed of a DC motor is directly proportional to beck emf, E_b and inversely proportional to flux per pole.

$N = k.\ \frac{Eb}{\phi} = k\ V—RI_a$ (neglecting brush drop)

where N = speed of motor in r p m

V = applied voltage across armature circuit

R_a = armature resistance

R_t = external resistance in armature circuit

$R = (R_a + R_t)$

I_a = Armature current

K = constant

From the above equation, it is clear that with constant supply voltage the speed of a DC shunt motor may be varied by

(i) changing the flux/pole, i e. by varying the field current.

(ii) changing R_t, the external resistance in the armature circuit

An important relation of DC motor is that the torque is directly proportional to the product of flux per pole and the armature current $T = k'\phi I_a$ where k' is a constant

Field Control
(Field Current Control)

By inserting resistance in the shunt field circuit, the field current will reduce, which in turn will reduce θ. Reduction in θ will result in speeds higher than normal Hence, speeds more than the normal speed can be obtained by field control

Armature Resistance Control
(Rheostatic control)

By inserting resistance in the armature circuit, reduced voltage is applied to the motor armature, which in turn reduces the speed of the motor. Hence, this method of speed control gives speeds less than the normal speed.

Equipment and Materials

(i) DC shunt motor

(ii) Three point starter

(iii) Low resistance rheostat rated for the armature current or higher current capacity.

(iv) High resistance rheostat rated for the field current of the motor.

(v) Voltmeter (0-250 V d c.)

(vi) Tachometer

(vii) Ammeter of suitable rating for field circuit.

(viii) Ammeter of suitable rating for armature circuit.

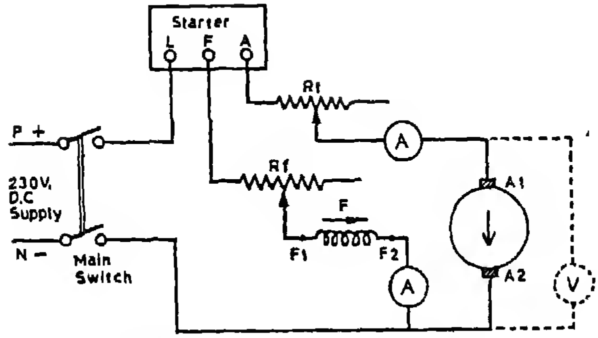


Fig 20.1 **D C Shunt motor speed control**

Procedure

(i) Connect the motor as shown in Fig. 20.1.

(ii) Set R_t and R_f at zero value (all resistance out) speed control by field control

(iii) Switch on the supply

(iv) Start the motor by means of the starter

(v) When the motor speed is steady, record the speed, field current and voltage across the armature (Va)

(vi) Increase Rf gradually and at each step of change, note down the speed and field current. Do not exceed the safe speed of the motor. Normally, the run should be continued up to 120% of rated speed only.

(vii) Reduce Rf gradually to zero and check speed, field current and voltage across the armature.

B. Speed control by armature resistance control.

(viii) Gradually increase Rt. Note that the speed falls Record speed and voltage across armature.

(ix) Repeat the previous step for various values of Rt and armature voltage, till about 20% of the rated speed is obtained.
Keep a check on the armature current. Do not allow it to become excessive.

(x) Stop the motor by switching off the mains.

Tabular Record of Observations

(i) Motor H.P. =

(ii) Voltage Rating =

(iii) Current Rating =

(iv) Speed Rating =

(v) Speed control data (Field control) .

(a) Normal field current =
(b) Normal armature voltage, Va =
(c) Normal speed =

Rt and Rf are set at zero.

(A) Field Control

S.No	Field current I_f amps.	Va volts	N r.p m
(i)			
(ii)			
(iii)			
(iv)			
(v)			
(vi)			
(vii)			
(viii)			
(ix)			
(x)			

(B) Armature resistance control

S.No	Field current I_f(amp).	Va Volts	N r p m
(i)			
(ii)			
(iii)			
(iv)			
(v)			
(vi)			
(vii)			
(viii)			
(ix)			
(x)			

Precautions

(i) Ensure that the starter handle is in the 'OFF' position before starting the motor.

(ii) Ensure that the field circuit is properly-connected before starting the motor.

(iii) Ensure that the ratings of ammeters, voltmeter and the rheostats are correct.

Questions

(i) Which type of starter is used to start a shunt motor?

(ii) For obtaining motor speeds higher than the normal, which method of speed control should be used ?

(iii) How will you select the rheostats for the field and armature circuit ?

(iv) What is the material used for winding the rheostats ?

(v) How do you select the rating of the ammeters and voltmeters used in the experiment ?

(vi) How will you decide the rating of the fuse to be connected in the main switch ?

(vii) Have you heard of any other method of speed control which is different from field or armature control discussed in this experiment ?

Dismantling and Reassembling of an Electric Geyser

Specific Objective

(i) To dismantle and reassemble an electric geyser

(ii) To examine various parts of an electric geyser.

(iii) To energize a geyser and to study its operation

4. To trace the fault inside a geyser

Related Information

An electric geyser is an appliance used to heat water by using electric energy Usually, geysers of the capacity of 5 litres, 10 litres and 50 litres are available The following are the parts of geyser :

(i) Metal water tank

(ii) Metal cover

(iii) Heating element

In good quality geysers, tanks made of copper with tinned inner side are used However, steel tanks with nickel plating on the inner side are also used. The outer side of the tank may be painted with red lead.

In order to protect the hot water in the metal tank from heat loss, a metallic cover is provided around the metallic tank. Between the cover and the tank, an 8 cm wide space is left all around the tank. This space is filled with glass wool Glass wool acts as a heat insulation medium for geyser

The heating element is fitted a little above the bottom from the side of the tank. Various types and sizes of heating elements are used However, the 'tube-type' element is in common use This type of heating element is fitted inside a tube which is full of magnesium oxide. Magnesium oxide acts as an insulator and prevents the elements from touching the walls of the tube. The bottom head of the tube is fitted with a bakelite connector which is fitted with the connecting pins for the heater element. A detailed diagram for a typical geyser is shown in Fig. 21.1. The hot water outlet is arranged in syphonic manner, so that to make hot water available to the initial water level must reach level A The water level cannot be reduced below level B which ensures that the heating element will always be inside the water.

The thermostat fitted in a geyser controls the temperature of water automatically and, thus, safeguards the whole unit from overheating. As soon as the temperature of the water inside the tank reaches 85^0 the heating element is automatically disconnected Electric connection is automatically restored as soon as the temperature of water falls.

As the water heating capacity of a geyser increases the electric power consumtion also increases A typical rating for a geyser is . 230/250 volt AC 50 litres, 2000 W

Equipment and Materials

(i) An electric geyser
(ii) Electrician's tool kit
(iii) Test lamp
(iv) Megger
(v) Multimeter

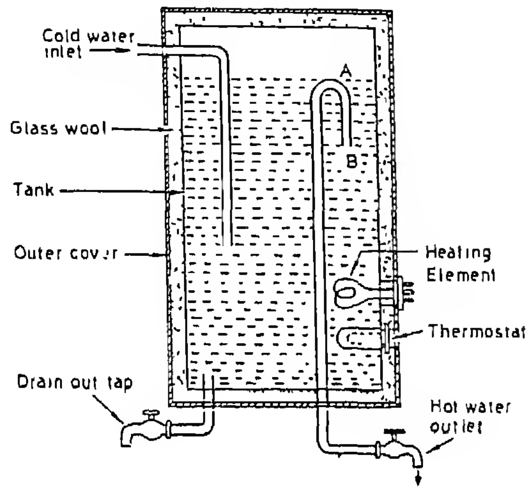


Fig 21.1 Geyser

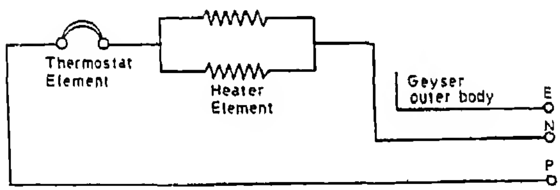


Fig 21.2 Heater element connection of a Geyser

Procedure

(i) Disconnect the geyser from the supply mains
(ii) Drain out all the water from the geyser
(iii) Test for electrical leakage with the help of a megger.
(iv) Open the clamps to remove the heater and thermostat from the geyser. Remove the earth connection.
(v) Check the continuity of the heater element.
(vi) If there is any scale formation around the heater tube, remove it (use hydrochloric acid solution to remove the scales).
(vii) Fit in the heater element and thermostat to its original position. Connect the earth wire
(viii) Recheck the geyser assembly against any electrical leakage.
(ix) Open the inlet tap until the water tank is filled with water.
(x) Close the inlet tap and switch on the electric supply to the unit

(xi) Wait for two to three minutes and then open the inlet tap and outlet tap. Check for the continuous flow of hot/warm water.

(xii) Close the water outlet tap and switch off the supply to the geyser.

Tabular Record of Observations

(i) Voltage rating of the geyser =

(ii) Water storage capacity =

(iii) Electric power rating =

(iv) Current drawn by the geyser =

(v) Rating of the fuse wire connected in the fuse switch connected to geyser =

(vi) Total monthly electric energy (in units) drawn by the geyser, if it remains on for 6 hours a day =

Precautions

(i) Do not touch the geyser when the power supply is ON.

(ii) Check that the body of the geyser is electrically insulated before and after dismantling the geyser.

(iii) Check that the geyser tank is filled with water before switching on the electric supply to the geyser.

(iv) Disconnect the electric supply from the geyser before leaving the laboratory.

(v) When the geyser is not to be used for a long time, the water in the tank should be drained out by unscrewing the drain plug.

Questions

(i) What is the difference between an instant geyser and a storage type geyser ?

(ii) When we switch on the power supply to a geyser, a voltage dip on the supply mains in observed (the light in the electric lamps gets dim). Why does this happen ?

(iii) What will happen if the thermostat element fails to operate ?

(iv) What type of heating element is used in a geyser ?

(v) What is the function of a pressure valve fitted at the top (lid) cover of some geysers ?

(vi) How does the rate of water flow in the inlet pipe of the geyser, affect the temperature control ?

(vii) What maintainance do you suggest for a geyser ?

(viii) Can a geyser work if DC supply is available in place of AC supply ?

Dismantling and Reassembling of an Electric Iron

Specific Objectives

To dismantle and reassemble an automatic electric iron.

Related Information

An electric iron is an important household electric appliance. There are two types of electric irons namely (a) simple electric iron and (b) automatic electric iron.

(a) Simple Electric Iron

An electric iron has the following parts which are assembled together Fig. 22.1.

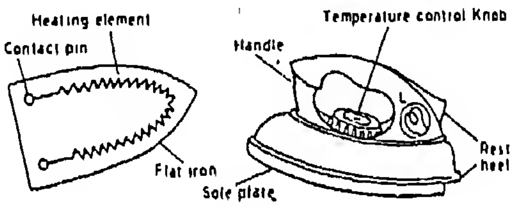


Fig 22 1 Electric Iron

(i) ***Sole Plate :*** The sole plate is the base-plate of the electric iron with the bottom side nickel-plated. There are two threaded holes at the top of the base-plate to fit the cover plate of the electric iron.

(ii) ***Heating Element :*** The heating element consists of a nichrome wire completely enclosed inside a mica insulation

(iii) ***Pressure Plate :*** The pressure plate is made up of a cast iron plate of the shape of the heating element. Its size is slightly larger than the heating element. It keeps the heating element in a compact and stationery state while the electric iron is in motion.

(iv) ***Cover :*** A sheet metal cover is used to cover the body of an electric iron.

(v) ***Handle :*** A bakelite handle is fitted with the cover of an electric iron.

(b) *Automatic Electric Iron*

An automatic electric iron is fitted with a thermostat which controls the temperature automatically.

A thermostat is a switch which operates automatically. It has a bimetallic element which bends when the temperature exceeds a pre-set limit. An adjustable screw or knob sets the temperature that should be maintained by the thermostatic control.

Equipment and Materials

(i) An automatic electric iron.
(ii) Voltmeter, 0-250 AC
(iii) Screwdriver
(iv) Pliers
(v) Test lamp
(vi) Multimeter
(vii) Megger

Procedure

(i) Examine the various parts of an electric iron.
(ii) Disconnect it from the mains (if already connected to supply mains).
(iii) Open all nuts and remove the handle and cover of the iron from the main body.
(iv) Remove the pressure plate of the iron.
(v) Take out the heating element along with the mica insulation.
(vi) Take out the bimetallic element.
(vii) Measure the resistance of the heater element.
(viii) Reassemble all the parts of the electric iron.
(ix) Test the insulation value of the terminals with respect to the body of the electric iron
(x) Connect the electric iron to the supply mains.
(xi) Measure the current flowing into the heater element.

Tabular Record of Observations

(i) Ohmic value of the resistance of the heater element . ohms
(ii) Magnitude of the current drawn by the iron .... amps (Use a clip-on meter)
(iii) Supply voltage . volts.
(iv) Electric power drawn by the electric iron . . watts
(v) Nameplate power rating of the electric iron . watts

Precautions

(i) Ensure that the electric iron is disconnected from the mains before you handle it
(ii) Choose the instruments of proper range while measuring current, voltage.
(iii) While reassembling the electric iron, ensure that the heater element is placed at its original position, with its insulation intact
(iv) Check the earth connection of the iron.
(v) The electric iron should not be allowed to get too hot, otherwise the nickel plating on the sole-plate will get damaged

Questions

(i) Why is a 3 wire cord used to connect an electric iron to the mains ?
(ii) How does a thermostat work ?
(iii) Draw a neat circuit diagram for a thermostat connection inside an electric iron.
(iv) Which material is used to manufacture the heater element of an electric iron ?
(v) What is the material used for making the sole-plate and pressure plate ?

ACTIVITY NO. 23

Plotting of Magnetic Field

Specific Objectives

(i) To learn to set the magnetic meredian and fix paper with bar magnet in the direction of the magnetic meredian

(ii) To plot magnetic lines of force around bar magnet parallel to the magnetic meredian using a compass.

(iii) To plot magnetic lines of force around the bar magnet aligned perpendicular to the magnetic meredian using a compass

(iv) To study plotted magnetic lines of force around bar magnet

Related Information

The lines of magnetic force are supposed to emerge out of the North pole of a magnet and travel towards its south pole These flux lines can be traced for any type of magnet (horseshoe, C magnet, bar magnet, rod magnet, etc) using either iron filings or mini compass needles. These lines of force are affected by the magnetic meredian i e the earth's magnetic field and also by nearby electromagnetic fields and ferrous metals in the surroundings.

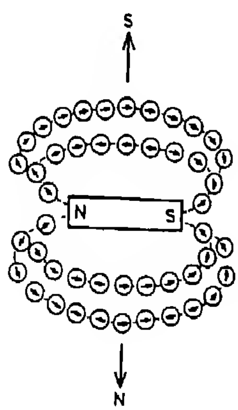


Fig 23 1 Magnetic lines of force (Parallel to magnetic meridian)

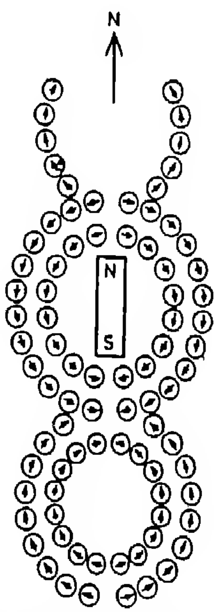


Fig. 23 2 Magnetic lines of force (Perpendicular to magnetic meridian)

Equipment and Materials

Compass needles — 3 Nos.
Bar/rod magnet — 1
Drawing sheet quarter imperial size — 1
Pencil and eraser
Cellotape

Procedure

(i) Fix up the drawing sheet on the board. Find out the magnetic meredian i.e. geographical north and south pole and mark then correctly on the sheet. Use a magnetic compass for finding the magnetic meredian

(ii) Place and fix rod/bar magnet parallel to the magnetic meredian, using cellotape.

(iii) Mark points, step by step, in the line of N and S of magnetic needle as shown in Fig. 23.1 using a number of magnetic compass needles. Draw dash lines joining the points — after completion.

(iv) Fix up new or reverse side of the same drawing sheet and adjust the magnet perpendicular to the magnetic meredian Use cellotape for fixing sheet and magnet

(v) Mark points at N and S poles of compass needle as shown in the Fig. 23.2 using a number of magnetic compass needles. Draw dash lines joining the points after completion.

(vi) Observe and study the magnetic field, effects of geographical N and S poles in the directions of magnetic lines.

Effect of meredian on magnet perpendicular to magnetic meridian	Effect of magnetic meredian on magnet parallel to megnetic meredian	Effects of iron and steel bodies in surroundings and electromagnetic fields
Magnetic lines pass straight undisturbed towards south pole of bar magnet These lines are curved in nature See Fig 23 2	Magnetic lines pass from N and S poles of bar/rod magnet, pass straight towards geographical N and S poles rather thatn going towards S pole of of magnet See Fig 23 1	Magnetic lines travelling from N pole of rod/bar magnet do not directly reach towards S pole, but these lines of force are disturbed and travel in a haphazard manner, having magnetically neutral points in between.

Precautions

(i) Do not drop the permanent magnets on the floor — this will make them lose their magnetic properties.

(ii) Do not heat the magnets — this will damage them

(iii) Do not keep iron and steel bodies near the magnet while drawing/plotting magnetic fields around magnets.

(iv) There should be no electromagnetic fields around the bar magnet.

Questions

(i) Permanent magnets are made of .. (a) silicon — stalloy, (b) carbon stalloy, (c) stalloy, (d) cobalt stalloy, (e) phosphorous bronze alloy, (f) non-ferrous metals.

(ii) Why dos a perment magnet lose its magnetism when harmered or dropped on the floor?

(iii) By heating the magnets, their magnetic strength is reduced (True/False)..

(iv) What are the effects of magnetic meredian on the magnetic field around the magnet kept (a) perpendicular to it (b) parallel to it ?

ACTIVITY NO. 24

Visit to a Hydroelectric Power Station

Specific Objectives

(i) To visit dam site/Forebay tank/water reservoir/canal, etc.
(ii) To study the operation of a turbine.
(iii) To study the operation of a generator unit
(iv) To study the cable connections from generator to power transformer.
(v) To study electric equipment in the outdoor switch yard and connection to Transmission/Distribution lines.

Related Information

An electric generator converts mechanical energy into electric energy. The mechnical energy (for driving or rotating the generator) is supplied to the generator by a primemover such as steam turbine, hydraulic turbine, etc Steam turbines are used in thermal power stations, whereas hydraulic turbines are used in hydroelectric power stations. When the water strike the blades of a water turbine, the turbine rotates. As the generator is mechanically coupled with the turbine, it also rotates along with the turbine. The amount of electric power generated by the generator depends upon the quantity of water available and the water head

The generator unit is made up of two parts namely : the stator and the rotor The exciting coils and the field poles of the generator are situated on the rotor which rotates along with the turbine The stator part does not rotate. Electric power output is obtained from the stator (winding) part of the generator.

The field coils (situated on the rotor) are connected to the excitor through slip-rings The exciter is a DC generator mounted on the same shaft on which the turbine and generator rotor are mounted

Connections from the generator are brought out to the primary winding of a power transformer by means of a three core cable. Usually, terminal voltage of a generator is 11 KV, whereas the transmission voltage may be of the order of 66 KV, 132 KV, 220 KV, 400 KV etc. Hence, a step-up power transformer is used at the power station site

From the transformer secondary (high voltage side) the connections to overhead lines are made through isolators and circuits breaker. An isolator is a switch which is operated when the load is off. A circuit breaker is an automatically controlled switch which operates on load or even on a fault.

A typical layout diagram of a hydroelectric power station is given in Fig 24 1. However, the student is advised to draw a detailed layout diagram of the power station that he has visited

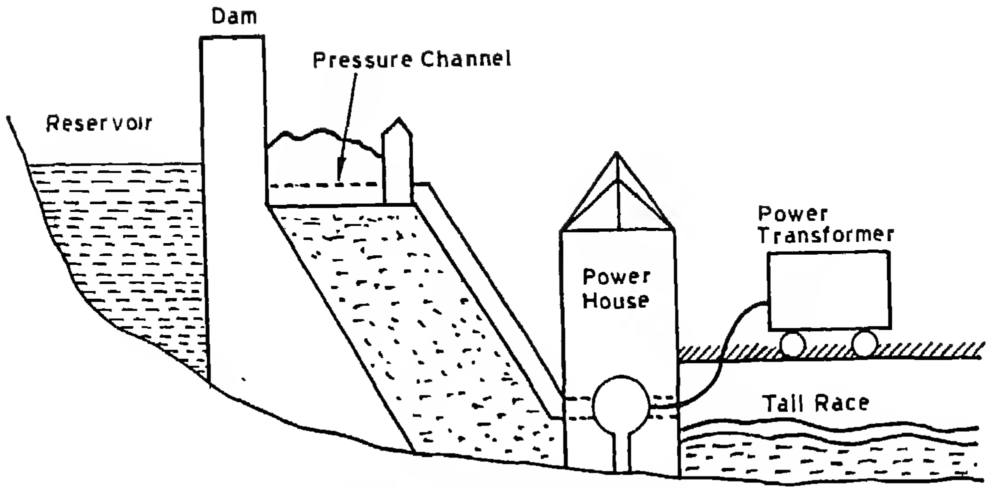


Fig. 24 1 Hydroelectric Power Station

Procedure

Visit the following sections of the power house and take note of the various equipment that you come across

(i) Dam site/Canal Headworks/Water Reservoir/Forebay tank
Watch the control of water flow from the main source of water to penstock.

(ii) Penstock installation.

(iii) Power House
- (a) Sluice gate;
- (b) Hydraulic turbine (inlet/outlet)
- (c) Tail race;
- (d) Bearings;
- (e) Generator unit,
- (f) Specifications of the generator unit.
- (g) Number of generating units;
- (h) Exciter;
- (i) Control room,
- (j) Governor control;
- (k) Overhead crane;
- (l) Cable connections outgoing from the generator

(iv) Outdoor Switch Yard .
- (a) Cable trenches;
- (b) Circuit breakers;
- (c) Power transformer (Primary, Secondary and Buchholz's relay);
- (d) Lightning arrestors;
- (e) Current transformer;
- (f) Potential transformer;
- (g) Grounding mat;
- (h) Isolator

Transmission Line

- (a) Line insulators
- (b) Line conductors
- (c) Power line carrier communicated equipment
- (d) Transmission tower
- (e) Vibration dampers on transmission lines.

Tabular Record of Observations

(i) Specifications of generator unit

M.V A Rating =
Voltage Rating =
Current Rating =
Speed of Rotation =
Frequency =

(ii) *Specifications of power transformer*
Primary voltage =
Secondary voltage =
kVA or mVA rating =

(iii) *Number of generator units*

(iv) Number of feeders going out from the power station =

(v) Peak load of the power station =

(vi) Head of water at the power station =

(vii) Rate of water flow in the penstock pipeline =

(viii) Diameter of the penstock pipe =

(ix) Transmission voltage =

(x) Material of the transmission line conductor =

(xi) Number of strands in transmission line conductor =

(xii) Distance of transmission =

(xiii) Type of insulator used on the transmission line

(ix) Number of discs in the insulator string =

Precautions

(i) Do not touch any equipment in the power station.

(ii) Do not crowd up around any equipment in operation in the power house

(iii) Do not move around the power station without the company of a technical expert from the power house

Questions

(i) Is the speed of a generator constant ?

(ii) Is the shaft of a generator set vertical or horizontal ?

(iii) How is the voltage induced in the starter winding ?

(iv) What is the importance of a power transformer ?

(v) Does the power generated by an alternator remain constant during the 24 hours of a day ?

(vi) Are the various generator units in a power house interconnected electrically ?

(vii) How does the electrical power generated in a power station reach various consumers of electrical power ?

(viii) What is the frequency of power supply ?

(ix) Does the generator generate AC voltage or DC voltage ?

(x) Draw a general layout of the power station that you have visited ?

(xi) Draw an electrical layout of the power station that you have visited

ACTIVITY NO 25

Visit to a Factory

Specific Objectives

(i) To expose students to an industrial environment

(ii) To observe electrical installations (wiring, eletrical motors, other electrical equipment)

Related Information

Every industry has two types of loads

(i) Power load

(ii) Lighting load

A fairly big industry has an outdoor/indoor substation. Every industry uses a large number of electrical motors for various purposes.

The teacher accompanying the pupils is required to explain about the electrical wiring of installation and process flow-diagram.

Procedure

(i) Follow strictly the safety precautions being observed in various sections

(ii) Do not touch any equipment without permission

(iii) Pick up the relevant information systematically

Tabular Record of Observations :

(a) Substation

- (i) Incoming voltage/outgoing voltage
- (ii) Rating .
- (iii) Types of cooling of transformer :
- (iv) Protection system.
- (v) Single-line diagram.
- (vi) Details of panel board.
- (vii) Methods of p.f. improvement

(b) Electrical Installation

- (i) No of distributing circuits.
- (ii) Types of wire used and their current rating.

(c) Motors

S.No	Type of the motor	H P	Type of starter	Method of speed control if any	Applications

(d) Other Electrical Equipment

S No.	Type of the equipment	Rating	Application

(i) Name of the product
(ii) Basic raw material used
(iii) Names of differt processes

S No	Name of the process	Input	Output

Precautions

(i) Visit the factory wearing proper clothes.
(ii) Do not disturb the normal working of the factory.
(iii) Follow strictly the safety precautions being observed in various sections.

Questions

(i) Explain service mains.
(ii) Name the types of the motors used.
(iii) Have you seen any DC motor?
(iv) Which type of speed control have you seen?
(v) Explain the method of protection of the individual motor.
(vi) How many workers are there in the factory?
(vii) Comment on the hygienic conditions in the factory.
(viii) What type of fire-fighting equipment is used in the factory?
(ix) Have you observed the first aid chart for electric shock?

ACTIVITY NO. 26

Visit to a Substation

Specific Objectives

(i) To study in detail the layout and the performance of the equipment in the yard.
(ii) To observe basic equipment and meters in the control room including the battery room.
(iii) To understand the basic duties of a lineman in a substation

Related Information

A substation is a very important part of the entire power systems. It is a link between the transmission and distribution systems. It needs regular maintenance and quick repair in case of fault A lineman has a very important role in the substation, particularly in the yard.

A modern substation is very complex in nature. It has various types of equipment for transmission distribution, protection and control of electrical power. All these are inter-connected in the substation. Since the voltage level is very high it is very important to take all precautions while working in the yard The lineman must observe the necessary safety precautions under all circumstances.

Sub-Stations are of three types.

Pole-mounted substation
Substation
Grid substation (GSS)

A blueprint of the substation/under study should be provided to the students

Procedure

(i) Identify various tupes of equipment installed in the substation as per its blueprint.
(ii) Prepare tabular records of your observations.
(iii) Follow the same procedure regarding the blueprint equipment in a grid substation

Tabular Record of Observations at Substation

(i) Incoming lines
Voltage:
No.of conductors.
Type of conductors:
Earth wire location:

(ii) Tower for incoming lines
Sketch of tower:
Height:
Type of conductors and insulators.

(iii) Insulators
Type:
Number per line:
Sketch:

(iv) Isolator
Location:
Number:
Operation.

(v) Circuit breaker
Type:
Rating:
Location:
Sketch the outer appearance:

(vi) Current transformer (C.T.)
Function:
Rating:

(vii) Potential transformer (P.T.)
Function:
Rating:

(viii) Busbar (H.V.)
Layout:
Function:

(ix) Lightning arrester
Function:
Location:

(x) Transformer
Voltage:
Rating:
Cooling:
Bushings:
Sketch of outer appearance:

(xi) Capacitor Bank
Function.
Rating:
Position:

(xii) Power-line-carrier communication (PLCC)
Basic function:
Loacation.

(xiii) Cable (L V. side)
Function.
Type:
Shape/cross-section:
Joints-type:
Repeat relevant observations for h.v. side.

(xiv) Feeders
Voltage:
Number.
Location

(xv) Control room
To take readings of various meters at the time of visit Indicate proper units.

1.

2.

3.

4.

5.

6

Relays

S No	Name	Basic Functions

(xvi) Battery room
Types of batteries
Total number of batteries
Working voltage
Function

(xvii) Protection against fire
Types of fire-fighting equipments

Location (a)
Maintenance (b)
(xviii) Duties of a lineman in a substation (c)

Precautions

(i) Follow strictly the instructions given by the guide while visiting a substation.
(ii) Do not touch any equipment.

Questions

(i) Why do lines (input-output) have different voltage levels?
(ii) Explain how 3 line conductors and the earth wire are arranged in a H.V line?
(iii) What is the basic function of a earth wire?
(iv) Is there any relationship between the height of the tower and operating voltage?
(v) Explain the relationship between the number of discs in an insulator and the operating voltage.
(vi) Explain clearly the function of an isolator and a circuit breaker.
(vii) Explain the sequence of operation of an isolator and circuit-breaker while: (a) making (b) breaking
(viii) Explain the function of (a) C.T (b) P T
(ix) Discuss the function of a busbar
(x) Explain the function of a lightning arrester
(xi) What are the duties of a lineman in the substations (various types)?
(xii) Explain the function of the following in a transformer
   (a) Bucholz's relay
   (b) Conservator tank
   (c) Breather
(xiii) Which equipment is responsible for the improvement of the power-factor?
(xiv) Why is a cable used in the substation?
(xv) Explain the feeder in a distribution system.

APPENDIX I

List of I.S.I. Books for Lineman

S No	Title	I S Code Nos
1	General and safety requirements for light electrical appliances	I S 302-1967
2	Climate proofing of electrical equipment	I S 3202-1965
3.	Code of Practice for Earthing,	I S 3043-1966
4	Electrical Wiring Installations (System voltage exceeding 650 volts)	I S 2274-1965
5	Installation & Maintenance of switch gear — Part I	I.S. 3072-1965
6	Installation & Maintenance of transformers	I S 1886-1967
7.	Hard-drawn copper conductors for O H Power transmission	I S 282-1963
8.	Hard-drawn Standard Aluminimum and Steel Cored Aluminimum Conductors for O H Power Transmission	I S 398-1961
9	Code Practice for Installation and maintenance of Paper Insulated Power Cables (upto and including 33 kv)	I S 1255-1967
10	Polythene insulated and P V.C sheathed cables	I S 1596-1962
11	Varnished Cambraic insulated cables	I S 693-1965
12	Drums for trolley & contact wire	I S. 2889-1964
13.	Trolley & Contact wire for electrical traction	I S 3476-1967
14	Insulation resistance tester (Hand operator)	I S. 2992-1965
15	Method of Impulse voltage testing,	I S 2071-1962
16	Method of Impulse voltage testing,	I S. 2070-1962
17.	Classification of Insulating materials for electrical machinery & apparatus in relation to their thermal stability in service	I S. 1271-1958
18	Dimensions for clamping arrangements for bushings	I S 4257-1967
19	Dimensions for disc insulators	I S. 3188-1965

20	Insulator fittings for O.H Power lines of 3 3 KV and above Part I, general requirements & test	I S 2486-1963
21	Porcelain insulators for O H Power Lines (3 3 KV and above)	I S 731-1963
22	Lightning arresters for A C system Part—I Non linear resistor type lightning arrestors	I.S 3070-1965 (Part I)
23	Lightning arrestors for A C systems Part II, explusion type lightning arresters	I S 3070-1965 (Part II)
24	Graphical symbols used in electro-technology Part V, generating stations and substations	I S 2032-1965 (Part V)
25	Graphical symbols used in electro-technology Part VII, Switchgear & auxilliaries	I S 2032-1965 (Part VII)
26	Electrical relays for power system Protection	I S 3231-1965
27	General requirements for electrical equipment of machine tools	I S. 1356-1964
28	Isolators and earthing switches, outdoor air break, for voltages upto 220 KV	I S 818-1961
29	Marking & arrangements for Switch-gear busbars, main connections and auxiliary wirings,	I S 375-1963
30	Three phase distribution transformers upto and and including 100 K V A 11 KV outdoor type	I S 1180-1964
31	Circuit Breakers, A C Part I, requirements, Section 2, Voltage range 1000 to 11000 volts.	I S 2516-1963 (Part I/Sec. 2)
32	Voltage and frequency for A C transmission & distribution systems	I S 585-1962
33	Danger notice plates	I S 2551-1963
34	Safety code for Excavation work	I S 3764-1966
35.	Fire safety of industrial buildings Electrical generating & distributing station	I.S 3034-1966
36	Lineman's Leather safety belt and straps	I S. 3521-1965
37.	Safety code for Scaffolds and Ladders Part I Scaffolds	I S 3969-1966 (Part I)
38	Safety code for Scaffolds and Ladders Part II Scaffolds	I S. 3969-1966 (Part II)
39.	Rubber gloves for electrical purpose	I.S. 4770-1968
40.	Methods of test for Concrete poles for O.H. Power and tele-communication lines	I S 2905-1966
41	Wood Poles for O H Power & Telecommunication	I S. 876-1961
42	Code of practices for Design & construction of foundation for transmission line towers and poles	I.S. 4091-1967

APPENDIX II

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